The Journal of Bone and Joint Surgery

The Official Publication of
The American Orthopaedic Association
The British Orthopaedic Association
The American Academy of Orthopaedic Surgeons
The Australian Orthopaedic Association
The Canadian Orthopaedic Association
American Society for Surgery of the Hand
New Zealand Orthopaedic Association
South African Orthopaedic Association

APRIL 1955

American Volume
Vol. 37-A, No. 2

8 THE FENWAY, BOSTON 15, MASSACHUSETTS, U. S. A.
BRITISH OFFICE:
82 PORTLAND PLACE, LONDON, W. 1, ENGLAND

The Journal of Bone and Joint Surgery

PUBLISHED IN TWO VOLUMES

The Journal of Bone and Joint Surgery

AMERICAN VOLUME

Editor, and *Chairman* of the Board of Editors:
WILLIAM A. ROGERS

American Board of Associate Editors

DAVID M. BOSWORTH, New York, N. Y.
THORNTON BROWN, Boston, Massachusetts
EDWARD L. COMPERE, Chicago, Illinois
MARK B. COVENTRY, Rochester, Minnesota
HAROLD E. CROWE, Los Angeles, California
G. W. N. EGGERS, Galveston, Texas
DAVID S. GRICE, Boston, Massachusetts
KEENE O. HALDEMAN, San Francisco, California
CHARLES H. HERNDON, Cleveland, Ohio
ROBERT A. KNIGHT, Memphis, Tennessee
CARROLL B. LARSON, Iowa City, Iowa
MICHAEL L. MASON, Chicago, Illinois
JOHN ROYAL MOORE, Philadelphia, Pennsylvania
I. WILLIAM NACHLAS, Baltimore, Maryland
FRED C. REYNOLDS, St. Louis, Missouri
ROBERT A. ROBINSON, Baltimore, Maryland
DONALD B. SLOCUM, Eugene, Oregon

The Journal of Bone and Joint Surgery

BRITISH VOLUME

SIR REGINALD WATSON-JONES, *Editor*

British Editorial Board

PROFESSOR WALTER MERCER, *Chairman*
PHILIP WILES, *Treasurer*
H. JACKSON BURROWS, *Deputy Editor*
J. CRAWFORD ADAMS, *Assistant Editor*
J. M. P. CLARK, Leeds, England
ALEXANDER GILLIES, Wellington, New Zealand
D. J. GLISSAN, Sydney, Australia
D. LL. GRIFFITHS, Manchester, England
A. R. HAMILTON, Sydney, Australia
R. I. HARRIS, Toronto, Canada
A. J. HELFET, Cape Town, South Africa
F. W. HOLDSWORTH, Sheffield, England
K. I. NISSEN, London, England
R. G. PULVERTAFT, Derby, England
N. W. ROBERTS, Liverpool, England
J. EDOUARD SAMSON, Montreal, Canada
J. C. SCOTT, Oxford, England
DENYS WAINWRIGHT, Newcastle-under-Lyme, England

WILLIAM A. ROGERS, *Editor-in-Chief*

Corresponding Editors

Argentina: JOSÉ VALLS
Austria: WALTHER EHALT
Belgium: JEAN VERBRUGGE
Brazil: F. E. GODOY MOREIRA
Cuba: ALBERTO INCLAN
Denmark: JOHANNES MORTENS
Finland: K. E. KALLIO
France: R. MERLE D'AUBIGNÉ
Germany: MATHIAS HACKENBROCH
Italy: O. SCAGLIETTI
Mexico: JUAN FARILL
Netherlands: J. D. MULDER
Poland: ADAM GRUCA
Portugal: ARNALDO RODO
Sweden: STEN FRIBERG
Uruguay: JOSE LUIS BADO

Committees

THE JOURNAL OF BONE AND JOINT SURGERY, INCORPORATED

The American Orthopaedic Association

The American Academy of Orthopaedic Surgeons

BOARD OF TRUSTEES

ROBERT W. JOHNSON, JR., *Chairman*
EDWARD L. COMPERE, *Vice-Chairman*
GUY A. CALDWELL, *Secretary*
DAVID M. BOSWORTH, *Treasurer*
WILLIAM A. ROGERS, *Editor*
JAMES S. SPEED
H. RELTON MCCARROLL

American Society for Surgery of the Hand

President: S. BENJAMIN FOWLER
President-Elect: L. D. HOWARD
Secretary-Treasurer: GEORGE V. WEBSTER
960 East Green Street, Pasadena 1, California

The Australian Orthopaedic Association

T. KING, Melbourne, *President*
WARWICK STENING, Sydney, *Editorial Secretary*
F. H. McC. CALLOW, *Secretary*, 141 Missenden Road, Sydney, New South Wales

The British Orthopaedic Association

BRYAN MCFARLAND, *President*
T. J. FAIRBANK, *Editorial Secretary*
J. I. P. JAMES, *Secretary*
45 Lincoln's Inn Fields, London, W.C. 2

The Canadian Orthopaedic Association

ALEXANDER GIBSON, Winnipeg
ROBERT I. HARRIS, Toronto
J. EDOUARD SAMSON, Montreal
F. P. PATTERSON, Vancouver
WILLIAM B. MACKINNON, *Secretary*
661 Broadway, Winnipeg, Manitoba

New Zealand Orthopaedic Association

MORRIS AXFORD, Auckland, *President*
HARMAN SMITH, Auckland, *Secretary*
ALAN ALLDRED, Dunedin
J. K. CUNNINGHAME, Wellington
N. NISBET, *Editorial Secretary*
Dunedin Hospital, Dunedin C.1, New Zealand

South African Orthopaedic Association

J. M. EDELSTEIN, *President*
W. T. ROSS, *Treasurer*
SIDNEY SACKS, *Secretary*
1010 Medical Centre
Johannesburg, South Africa

Published in the United States by The Journal of Bone and Joint Surgery, Incorporated

Copyrighted in the United States by The Journal of Bone and Joint Surgery, Incorporated

Published in the United Kingdom for The British Editorial Society of Bone & Joint Surgery Limited by E. & S. Livingstone, Teviot Place, Edinburgh

Copyright in Britain and the Commonwealth by The British Editorial Society of Bone & Joint Surgery Limited

THE JOURNAL OF BONE AND JOINT SURGERY

American Office
8 The Fenway, Boston 15, Massachusetts, U.S.A.
Assistant Editor: Florence L. Daland

British Office
82 Portland Place, London, W. 1, England
Editorial Secretary: Jean Barnes

The Journal of Bone and Joint Surgery*

American Volume

TABLE OF CONTENTS

April 1955

PAGE

Articular Replacement for the Humeral Head.
By *Charles S. Neer, II, M.D.*, New York, N. Y. 215

Early Weight-Bearing and the Correction of Anteversion in the Treatment of Congenital Dislocation of the Hip.
By *E. George Chuinard, M.D.*, Portland, Oregon 229

Further Experience with Extra-Articular Arthrodesis of the Subtalar Joint.
By *David S. Grice, M.D.*, Boston, Massachusetts 246

The Use of Radio-Active Phosphorus (P^{32}) to Determine the Viability of the Head of the Femur.
By *H. B. Boyd, M.D.; D. B. Zilversmit, Ph.D.;* and *R. A. Calandruccio, M.D.*, Memphis, Tennessee 260

Reconstruction of Hand Digits by Toe Transfers.
By *Patrick Clarkson, F.R.C.S.*, London, England 270

Comparison of Congenital Defects Induced in Developing Chickens by Certain Teratogenic Agents with Those Caused by Insulin.
By *P. K. Duraiswami, Ph.D., M.S., M.Ch.Orth., F.R.C.S.*, Baltimore, Maryland 277

Complementary Roentgenographic View of the Hip.
By *Thomas F. Broderick, Jr., M.D.*, Brookline, Massachusetts 295

The Place of Nerve-Grafting in Orthopaedic Surgery.
By *Donal Brooks, F.R.C.S.*, London, England 299

Complications and Failures in the Operative Treatment of Intertrochanteric Fractures of the Femur.
By *G. Mosser Taylor, M.D.; Alonzo J. Neufeld, M.D.;* and *Vernon L. Nickel, M.D.*, Los Angeles, California 306

Homogenous Bone Grafts in Spine Fusions for Tuberculosis.
By *Sidney N. Eichenholtz, M.D.*, and *Victor Mayer, M.D.*, Bronx, New York 317

Studies on Fracture Healing.
By *Hans H. Bohr, M.D.*, Copenhagen, Denmark 327

Arthritis Mutilans (*Doigt, Main, Pied en Lorgnette*).
By *H. B. Eisenstadt, M.D.*, Port Arthur, Texas, and *G. W. N. Eggers, M.D.*, Galveston, Texas ... 337

Transplantation of the Biceps Femoris to the Patella by the Medial Route in Poliomyelitic Quadriceps Paralysis.
By *Gene D. Caldwell, M.D.*, Shreveport, Louisiana 347

(Continued on page 3)

The Journal of Bone and Joint Surgery (American Volume) is issued six times a year—in January, April, June, July, October, and December. The 1955 subscription price, payable in advance, is $13.00. Single copies $2.50.

The Journal of Bone and Joint Surgery, entered as second-class matter August 1, 1921, at the Post Office, Boston, Mass., under the act of March 3, 1879. Editorial and business offices, 8 The Fenway, Boston, Mass. Accepted at the special rate of postage provided for in the act of February 28, 1925, Paragraph 4, Section 412, Postal Laws and Regulations; authorized April 21, 1932. Additional entry at Concord, New Hampshire, authorized June 10, 1947.

Copyright 1955 by *The Journal of Bone and Joint Surgery, Incorporated.*

* TITLE REGISTERED IN UNITED STATES PATENT OFFICE

Suggestions for Contributors

The Journal of Bone and Joint Surgery welcomes contributions of interest to orthopaedic surgeons from all countries of the world.

Manuscripts offered for publication in the American Volume should be sent to the Editor, *The Journal of Bone and Joint Surgery*, 8 The Fenway, Boston 15, Massachusetts.

Manuscripts submitted for publication in the British Volume should be sent to the Editor, *The Journal of Bone and Joint Surgery*, 82 Portland Place, London, W. 1, England.

Instructions to Contributors to American Volume

All articles are acknowledged as soon as received, and a reply is sent as to their disposition as soon as possible after that date. Since the manuscripts are read by members of the Board of Associate Editors and often are discussed at the meetings of the Board, there may be unavoidable delay.

Articles are accepted only with the understanding that they are contributions exclusively to this *Journal*.

Manuscripts

All manuscripts should be typewritten, with double spacing and good margins. The original should be submitted, the author keeping a copy, as the original of an accepted article will not be returned.

Figures under 100 should be written out, except when used for percentage or degrees, or where decimals are involved.

When direct quotations are used, they should include the exact page numbers on which they appeared in the book or article from which they were taken.

A list of legends for the illustrations should be included.

The bibliography should include only references mentioned in the text. It should be double spaced and arranged alphabetically, and the following forms used:

Reference to an article: author's name and initials, title of the article, name of periodical, volume number, inclusive pages, and year of publication.

Reference to a book: name of author and initials, title of book, edition number, city of publication, publisher, and year of publication.

Accuracy in the preparation of bibliographies will save much time and correspondence.

Illustrations

Careful consideration must be given to the number of illustrations accepted with each article. It is seldom necessary to republish illustrations.

Good illustrations in *The Journal* are only possible from good copy. Black and white glossy prints of photographs should be furnished. Direct-contact glossy prints from the original roentgenograms should be submitted. These usually reproduce more satisfactorily than do prints from secondary negatives.

The magnification of all photomicrographs should be given.

Original drawings should be furnished; photographs of drawings do not reproduce well. If there is printing on the drawings, it should be large enough to be readable after the necessary reduction.

All drawings and lettering on prints should be done in black India ink. Dates, initials, et cetera should be included in legends rather than inscribed on the face of the prints. Charts should be done in black India ink and the originals should be submitted, rather than photographs of the charts.

Prints should be submitted either unmounted or mounted with rubber cement. Many illustrations have to be discarded because they are defaced with paste or glue.

All illustrations should be numbered, the top plainly indicated, and the author's name written on the back of each.

If it is necessary to reproduce an illustration which has appeared elsewhere, full information should be given as to the previous publication, with a statement as to whether or not permission has been obtained to reproduce the illustration.

Copyright

Material appearing in *The Journal* is covered by copyright; but, as a general rule, no objection will be made to the reproduction in reputable medical journals of anything in these pages, provided that permission has first been obtained from *The Journal* and that proper acknowledgment is made.

Original Articles

Papers will be accepted only for exclusive publication in this *Journal*, which does not officially endorse the opinions presented in the different papers.

Articles and their illustrations become the property of *The Journal*.

TABLE OF CONTENTS

(Continued from page 1)

PAGE

The Treatment of Experimental Arthritis in Rabbits with Hydrocortisone Acetate.
By *R. H. Ramsey, M.D.*, and *J. Albert Key, M.D.*, St. Louis, Missouri 354

Traction Arthrography of the Hip Joint. A Method of Roentgenographic Visualization of the Articular Space of the Hip Joint.
By *Samuel Schorr, M.D.*, and *Myer Makin, M.B., M.R.C.S.*, Jerusalem, Israel 361

Spontaneous Rupture of the Extensor Pollicis Longus Tendon Following the Fracture of the Carpal Navicular Bone.
By *Jack Levine, M.D.*, and *Monroe Schneider, M.D.*, Brooklyn, New York 364

The One-Bone Forearm. A Reconstructive Procedure.
By *R. A. Murray, M.D.*, Temple, Texas 366

The Attitude of the Physician toward Rehabilitation.
By *A. R. Shands, Jr., M.D.*, Wilmington, Delaware 371

Reflections on Some Interesting Personalities in Orthopaedic Surgery During the First Quarter of the Century.
By *Leo Mayer, M.D.*, New York, N. Y. 374

Proceedings:
The American Academy of Orthopaedic Surgeons 384

Presidential Address 385

Western Orthopedic Association 394

American College of Surgeons. The Forum on Fundamental Surgical Problems 410

Southern Medical Association. Section on Orthopaedic and Traumatic Surgery 413

Hospital for Joint Diseases. Alumni Meeting 416

Sociedad Argentina de Ortopedia y Traumatologia 422

Dr. Leo Mayer Retires from the Journal Board 422

Fremont A. Chandler 423

Henry Page Mauck 426

Charles Mayor Jacobs 428

News Notes 430

The Exchange Fellows 434

Book Reviews 435

List of Advertisers 70

Addresses of Contributors ..... Cover III

Subscription Rates for 1955

AMERICAN AND BRITISH VOLUMES—Combination price $20.00 or £6.00.0

American Volume, $13.00 or £4.00.0
Published January, April, June, July, October, December

British Volume, £3.00.0 or $10.00
Published February, May, August, November

All subscription rates include postage

Checks should be made payable to *The Journal of Bone and Joint Surgery, Inc.*
Microfilms of the American Volumes are available to regular subscribers through University Microfilms, 313 North First Street, Ann Arbor, Michigan.

THE JOURNAL OF BONE AND JOINT SURGERY

American Office
8 The Fenway, Boston 15, Massachusetts, U. S. A.

British Office
82 Portland Place, London, W. 1, England

to complement surgical skill

Bone Saw

Bone Drill

Rolo-Dermatome

OTHER WELL-KNOWN STRYKER PRODUCTS

TURNING FRAME • BONE SAW • CAST CUTTER • WALKING HEELS • AUTOPSY SAW • PLASTER DISPENSER •

with SAFETY . . . CONVENIENCE . . . VERSATILITY

THE NEW Stryker **ELECTRO-SURGICAL UNIT**

All these instruments now at the surgeon's finger tips

Color-Guide Screw Case

The Stryker Electro-Surgical Unit was designed to meet the operating room safety requirements of the National Board of Fire Underwriters – and yet eliminate the added bulk and cost of explosion-proofing all motors and switches, by placing them in the non-hazardous area (above five feet).

It also eliminates the cost of duplicating the motor in each power tool.

One power unit serves many specialties. Each surgeon need provide only the tools suited to his specialty and taste.

Color-Guide Drill Holder and Shield

Screw Driver-Stryker Automatic

Depth Gauge and Drill Guide

Rhinoplasty Saw- Seltzer

Dental Handpiece

Orthopedic

Write Dept. B for complete information

ORTHOPEDIC FRAME COMPANY

Kalamazoo Michigan

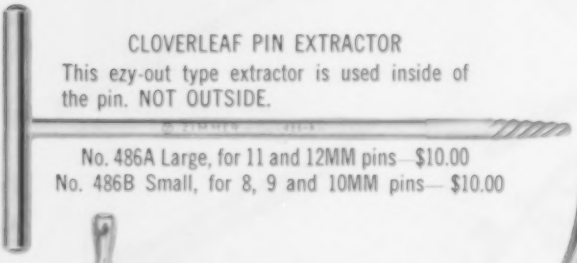
OVERBED FRAME • PORTABLE SUSPENSION TRACTION FRAME

ADVANCED *Zimmer* Instruments and Appliances for Orthopedic Surgery

No. 825
Schneider self broaching pin

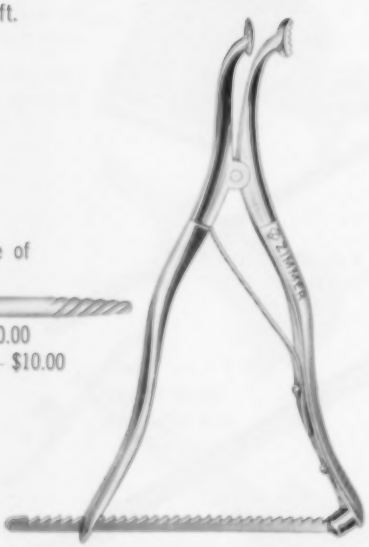
SCHNEIDER **SELF BROACHING** INTRAMEDULLARY PIN . . . . .

- No need for special instruments.
- Prevents rotation of fragments.
- Maximum strength for weight of pin.
- Cuts its own way—less chance of splitting the shaft.
- Larger sized nail can be used for a snug fit.
- May be driven or extracted from either end.
- Less chance of getting out of the groove.
- Grooves allow for free outflow of marrow fat.
- SIZES: 8mm. to 12mm. diameters.



CLOVERLEAF PIN EXTRACTOR
This ezy-out type extractor is used inside of the pin. NOT OUTSIDE.

No. 486A Large, for 11 and 12MM pins—$10.00
No. 486B Small, for 8, 9 and 10MM pins—$10.00



"Small Hand Drill"
No. 895
Price $45.00

Lamina Spreader
No. 661
Price $65.00

Zimmer

ZIMMER MANUFACTURING CO. WARSAW, IND.

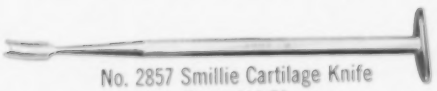
In Canada Available through selected surgical supply dealers or through our Agents, Fisher & Burpe, Ltd.

Look for the trademark

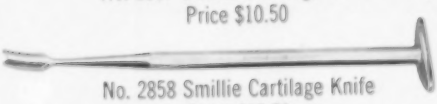
Zimmer Cartilage Instruments

No. 3745 Cartilage Scissors
Price $10.00

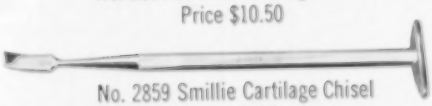
No. 3725
Martin Cartilage Clamp
Price $14.75



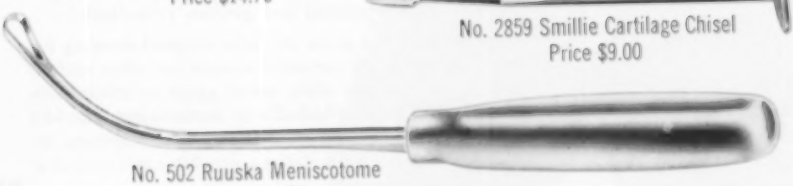
No. 2857 Smillie Cartilage Knife
Price $10.50



No. 2858 Smillie Cartilage Knife
Price $10.50



No. 2859 Smillie Cartilage Chisel
Price $9.00



No. 502 Ruuska Meniscotome
Price $18.50

No. 10-128 Grover Meniscotome
Price $24.00

No. 3700 Downing Cartilage Knife
Price $12.00

No. 388 Semilunar Cartilage Knife
Price $7.50

ZIMMER MANUFACTURING CO. WARSAW, IND.

In Canada Available through selected surgical supply dealers or through our Agents, Fisher & Burpe, Ltd.

Zimmer

Look for the trademark

AEROPLAST®

Brand of Vibesate

LIQUID SURGICAL DRESSING

is now accepted by the Council on Pharmacy and Chemistry of the American Medical Association

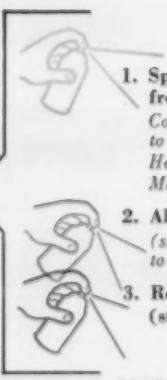
from the N. N. R. Monograph

"VIBESATE — (Aeroplast)

Vibesate is a modified polyvinyl plastic that forms a rapidly drying, transparent, pliable, and occlusive film when applied topically as a liquid spray containing a suitable volatile solvent and gaseous propellant.

Vibesate is useful as an occlusive surgical dressing for burns as well as for operative wounds and other surface lesions, particularly when use of gauze or other fabricated dressings is undesirable or inconvenient. The film also is suitable for covering certain skin eruptions, including macerated excoriations, decubitus and traumatic ulcers, and abrasions."

easy to apply



1. **Spray a light film onto aseptic dry wound from a distance of 6 to 12 inches.**
   Cover adjacent area of intact skin to provide anchorage.
   Hemostasis should be complete.
   May be applied over sutures.
2. **Allow film to dry for 30 seconds.**
   (sufficient time for the acetone solvent to evaporate)
3. **Repeat "spray and let dry" procedure (steps 1 and 2 above) two more times.**

Aeroplast is sterile

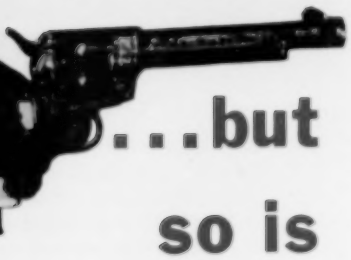
Supplied in 6 oz. aerosol-type dispenser.
Available through your surgical dealer or prescription pharmacy.

For literature and reprints write.

AEROPLAST CORPORATION • 422 Dellrose Avenue, Dayton 3, Ohio

In answering advertisements, please mention *The Journal of Bone and Joint Surgery.*

He's plenty tough this "hombre"



...but so is his cast

Tough enough to take all the abuse he may give it without cracking or buckling—rain and puddle-proof too—because it was made with the new

ZOROC
RESIN-PLASTER
BANDAGES

PRODUCT OF

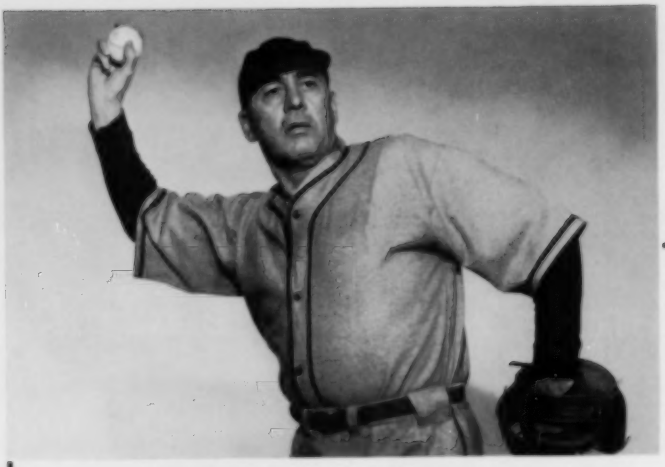
Johnson & Johnson

The new ZOROC has everything!

Plaster + Resin + Catalyst
. . . and it's all in the bandage

Just **dip** **squeeze** **apply**

Johnson & Johnson



Perfect Delivery

Lynco
TRADE MARK

Non-Metallic
Muscle-Building
Arch Cushions

Ashley
TRADE MARK

Posture Plates

FOR over thirty years, doctors have been relying on KLEISTONE to deliver perfection in every orthopaedic appliance. Skilled technicians with long experience combine meticulous attention with the highest quality materials to fashion appliances exactly as you prescribe.

AS a further co-operation with the medical profession, we also distribute record charts with special sensitized paper for actual foot impressions, at no extra cost.

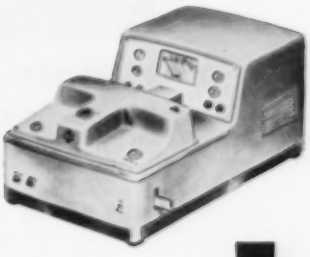
Our free catalogue will be sent upon request

KLEISTONE RUBBER COMPANY, Inc.
Established 1919
Warren, Rhode Island, U. S. A.

EXCLUSIVE ELECTRONIC SHARPOMETER...

***Guarantees* A·S·R BLADES**

THE SHARPEST EVER MADE!



The NEW EXCLUSIVE A. S. R. SHARPOMETER... **the only device of its kind in the world...** measures the CRITICAL EDGE-FINENESS of every lot of

A. S. R. SURGICAL BLADES

EDGE-FINENESS determines perfect cutting qualities. Sharpometer Edge-Fineness tests enable A. S. R. to ***guarantee*** . . . precise, uniform sharpness and dependability for every single blade!

NEVER AGAIN will the surgeon suffer embarrassment due to dull blades. A.S.R. SURGICAL BLADES . . . Sharpometer tested . . . *are your safe-guards.*

A.S.R.
PRECISION PRODUCTS

PROVED SHARPNESS: Sharpometer tests on competitive blades including re-sharpened ones, have proven . . . beyond a doubt . . . A.S.R. SURGICAL BLADES are uniformly sharper.

NO WIPING REQUIRED — blades are wrapped in rust inhibiting paper.

EVEN THE PRICE IS A PLEASANT SURPRISE

Telephone, write or telegraph NOW for New Descriptive Booklet — "SHARP SURGEONS' STEEL"

AMERICAN SAFETY RAZOR CORPORATION
HOSPITAL DIVISION
380 MADISON AVE., NEW YORK 17, N. Y.

HIBBS COMPLETE SET OF CHISELS, OSTEOTOMES AND GOUGES

Solid one-piece construction of the finest stainless steel. Perfectly tempered, hardened and balanced, with hexagonal handle for sure grip. These fine instruments will cut sclerotic bone easily without dulling the edges. May be purchased singly or in sets of nine sizes.

No. 132—Osteotomes No. 133—Gouges No. 134—Chisels

SIZES: 3/8″—1/2″—5/8″—3/4″—7/8″—1″—1 1/8″—1 1/4″—1 1/2″.

Available curved or straight.

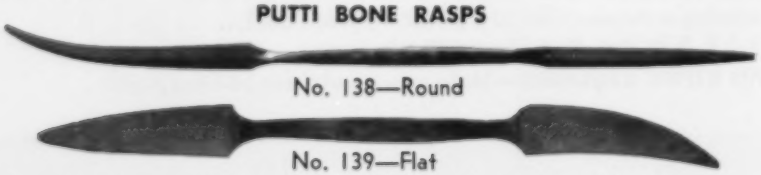
HOKE OSTEOTOMES

Constructed as above, for small work. No. 432—Curved or Straight. Sizes: 1/8″—3/16″—1/4″—5/16″—3/8″—1/2″.

KEY PERIOSTEAL ELEVATORS

Same construction as Hibbs instruments above. No. 131—Sizes: 1/4″—3/8″—1/2″—3/4″—1″.

PUTTI BONE RASPS



No. 138—Round

No. 139—Flat

Stainless Steel carrying cases for sterilizing are available at additional cost, if desired.

WRIGHT MANUFACTURING COMPANY

739 JACKSON AVENUE • TELEPHONE 37-2769 • MEMPHIS 5, TENNESSEE

In answering advertisements, please mention *The Journal of Bone and Joint Surgery.*

a local anesthetic that has come so far . . . so fast*

XYLOCAINE® HCl

(Brand of lidocaine* hydrochloride)

ASTRA

Council Acceptance is your assurance of high professional standards.

for **INFILTRATION**
NERVE BLOCK
TOPICAL USE

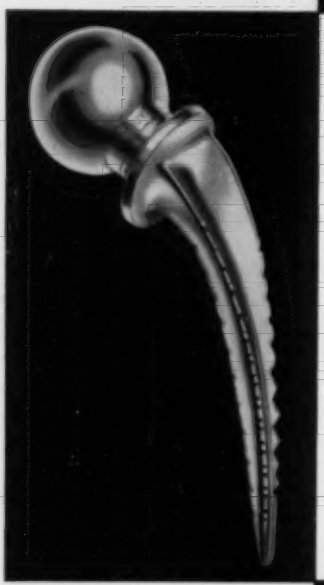
* *Write for 200 reference bibliography available to physicians on request.*

*U.S. Pat. No. 2,441,498

ASTRA PHARMACEUTICAL PRODUCTS, INC.
Neponset Street Worcester, Mass.

DePuy

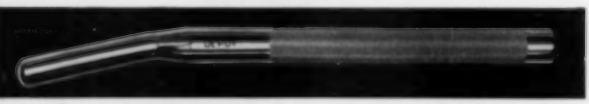
ANNOUNCES

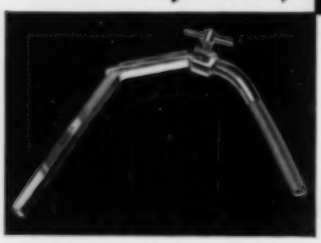


● MODIFIED SCUDERI HIP PROSTHESIS

This new hip prosthesis set reflects important improvements over preceding units. Ball portion, or head, and washer are detachable from stem, or nail. Allows different sizes of femoral heads to be fitted without removing the entire unit. Ball portion is hollowed out, fitting over the stem portion, which allows movement of the ball even after it has become frozen in the socket. Can be used with or without removable washer, which affords greater or less length, whichever is needed. Collar on stem enables weight to bear on femoral neck. Stem is available in two sizes, large and medium. Generally requires smaller canal, meaning less reaming, than other hip prosthesis units. Stem fins have serrated edges, which assure firm implanting. Entire unit is made of polished SMO Stainless Steel, carefully tested for imperfections, including the ZYGLO-PENTREX test method in our Magnaflux Certified Laboratory. Application technique is same as on any stem portion hip prosthesis. No. 618A, complete with stem, ball, and washer (specify diameter of ball, 1⅝", 1¾", or 1⅞"; and whether medium or large stem).

Since 1895 - - the Standard of Quality





DePuy DRIVER FOR INSERTING HIP PROSTHESIS

Made of stainless steel, this Driver is designed for use with Modified Scuderi Hip Prosthesis. Fits into hollowed portion at top of stem, eliminates danger of damage to highly polished outside. No. 563.

DePuy PLATE BENDING IRON AND PLATE HOLDER

Design of DePuy Bone plates is based on latest engineering and medical knowledge, but bending is occasionally necessary. The unit shown at left simplifies such bending. Plate Holder has winged-head screw, which has polished convex end. Holds plate with vise-like grip, yet does not mar plate surface. Sturdy Bending Iron has long, channeled end to receive plate, and assures bend at proper point. Curved design of entire unit affords lever action in bending, minimum effort required. Constructed entirely of stainless steel. Bending Iron No. 600. Plate Holder No. 605.

Write **FOR COMPLETE CATALOG! OVER 150 ILLUSTRATED PAGES OF SUPPLIES FOR THE ORTHOPEDIC SURGEON.**

DePuy **MANUFACTURING CO., INC.**

WARSAW (8) INDIANA

our 60th year 1895 1955 DePuy

Shoe Construction Orthopedists Appreciate

WEDGE CONSTRUCTION

ALLOY SPRING STEEL SHANK

BROAD BASED HEEL

● Orthopedists appreciate the design and construction of Selby Junior Arch Preserver Shoes because they are built to meet the special needs of infants and children.

Selby Junior Arch Preservers are made on broad toed lasts, skived out on the inner border to accommodate wedging. They have a broad heel base and ball tread. Shoes from sizes 8½ up have lightweight alloy steel shanks that afford a sturdy base for additional inlays when indicated by the doctor. All shoes are made of light, strong, flexible, long-wearing, highest quality leathers, with soft, smooth, supple kidskin linings.

The excellence of Selby Junior Arch Preservers is the result of knowledge and skill acquired in more than three quarters of a century of fine shoemaking.

When you recommend shoes for infants and children, please remember — Selby Juniors are the only genuine Arch Preserver Shoes for children.

● *If Selby Junior Arch Preservers are not available in your city, please write directly to us.*

The Selby Shoe Company
Portsmouth, Ohio

Selby
JUNIOR ARCH PRESERVER SHOES

MORE THAN THREE QUARTERS OF A CENTURY OF FINE SHOEMAKING

In answering advertisements, please mention *The Journal of Bone and Joint Surgery.*

Now you can do more for

Stress Fortified

The availability of such anti-infectives as Terramycin, Tetracyn and penicillin has not altered the wise admonition to "treat the patient as well as the disease." As the National Research Council[1] has emphasized, certain water-soluble vitamins (B-complex and C) and vitamin K are involved in body defense mechanisms as well as in tissue repair and are required in increased amounts during the stress of febrile infections. Yet there is often a considerable reduction in the normal supply of these important nutritional elements in acutely ill patients who are candidates for antibiotic therapy.

Unique new Stress Fortified Terramycin-SF, Tetracyn-SF and Pen-SF contain the stress vitamin formula recommended by the National Research Council[1] for therapeutic use during sickness or injury as a significant contribution to rapid recovery and convalescence. The patient is assured the maximum benefits of modern antibiotic therapy plus the needed vitamin support – without additional prescriptions, and at little additional cost.

1. Pollack, H., and Halpern, S. L.: Therapeutic Nutrition, Prepared with Collaboration of the Committee on Therapeutic Nutrition, Food and Nutrition Board, National Research Council, Baltimore, Waverly Press, 1952.

the patient with infection...

not only fight the infection,

but also Stress Fortify the patient

with a *single* prescription of

®Terramycin-SF

Brand of oxytetracycline with vitamins

CAPSULES (250 mg.)

®Tetracyn-SF

Brand of tetracycline with vitamins

CAPSULES (250 mg.) ORAL SUSPENSION (fruit flavored)
(125 mg. per 5 cc. teaspoonful)

CAPSULES (200,000 units) **Pen-SF***

Brand of penicillin G potassium with vitamins

The minimum daily dose of each antibiotic
(1 Gm. of Terramycin or Tetracyn,
or 600,000 units of penicillin)
Stress Fortifies the patient
with the stress vitamin formula
as recommended by
the National Research Council...

Ascorbic acid, U.S.P.	300 mg.
Thiamine mononitrate	10 mg.
Riboflavin	10 mg.
Niacinamide	100 mg.
Pyridoxine hydrochloride	2 mg.
Calcium pantothenate	20 mg.
Vitamin B_{12} activity	4 mcg.
Folic acid	1.5 mg.
Menadione (vitamin K analog)	2 mg.

for little more than the cost of antibiotic therapy alone

*Trademark

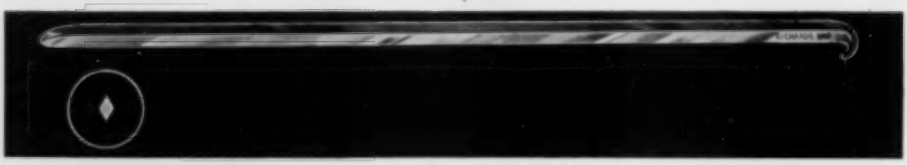
available only from **Pfizer**

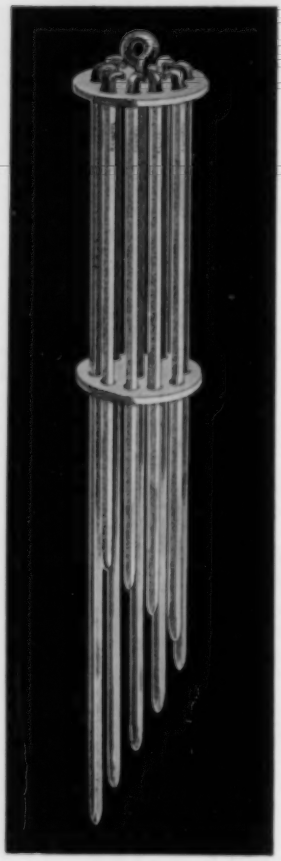
PFIZER LABORATORIES, Brooklyn 6, N.Y.
Division, Chas. Pfizer & Co., Inc.

The Richards **DIAMOND** *Intramedullary Nails*

For

18-8 smo Stainless (type 316) *Fractures of* { TIBIA, HUMERUS, RADIUS, ULNA, PHALANGES, FEMUR } **No Rotation Of Fragments**





TIBIA	**Lower Third of Femur**	Complete Set	$54.00
SET #1 No. 204	Each set consists of 9 Lengths 8", 8¾", 9½", 10¼", 11", 11¾", 12½", 13¼", 14" Diameters: 4mm x 6mm	Each Pin	$ 6.00
HUMERUS	(Same as set #1 except 2 diameters)	Complete Set	$54.00
SET #2 No. 205	Each set consists of 9 Lengths 8", 8¾", 9½", 10¼", 11", 11¾", 12½", 13¼", 14" Diameters: 4mm x 6mm, 3mm x 5mm	Each Pin	$ 6.00
RADIUS & ULNA	**(Neck of Humerus, condyles of Tibia, Humerus and Femur)**	Complete Set	$52.00
SET #3 No. 206	Each set consists of 13 Lengths 4", 4½", 5", 5½", 6", 6½", 7", 7½", 8", 8½", 9", 9½", 10" Diameters: 3mm x 5mm, 2mm x 3mm	Each Pin	$ 4.00
Phalanges	**Clavicle, Jaw, Metacarpals, Condyles**	Complete Set	$26.00
SET #4 No. 207	Each set consists of 13 Lengths 1", 1¼", 1½", 1¾", 2", 2¼", 2½", 2¾", 3", 3¼", 3½", 3¾", 4" Diameter: 2mm x 3mm	Each Pin	$ 2.00
FEMUR	(For inserting below trochanter)	Complete Set	$67.50
	Each set consists of 9 Lengths 11", 11¾", 12½", 13¼", 14", 14¾", 15½", 16¼", 17" Diameter: 7mm x 9mm	Each Pin	$ 7.50

Every Orthopedist and General Surgeon has found to his own satisfaction that a diamond shaped pin will not permit fragmental rotation as the round pins cannot prevent. Therefore, here is what you have been wanting for a long time. They have been proven over the years since World War II.

Check with yourself all the above advantages in each phase of your fracture work.

Without doubt you will start using these as soon as possible, to your own and your patients' complete satisfaction.

Manufactured Exclusively By

RICHARDS MANUFACTURING COMPANY

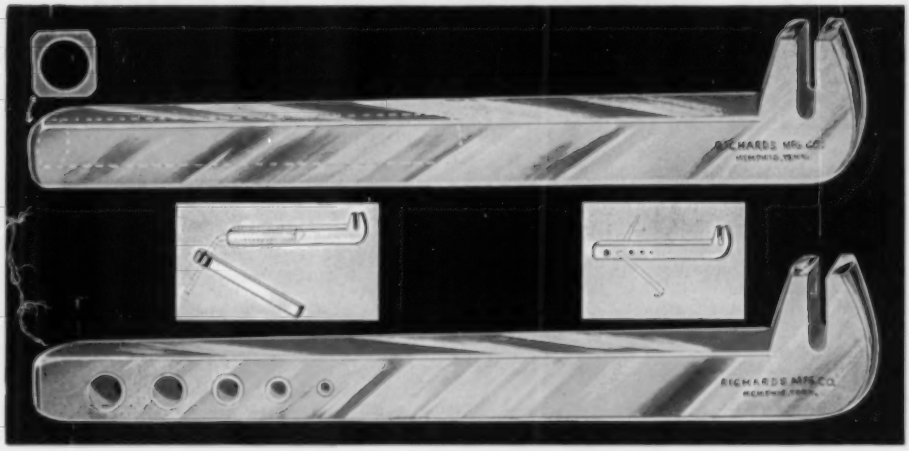
The Complete Orthopedic Supply House

756 MADISON AVE. **PHONE 8-2566**

MEMPHIS 7, TENN.

COPYRIGHT 1953—ALL RIGHTS RESERVED—RICHARDS MANUFACTURING COMPANY

JEWETT BENDERS



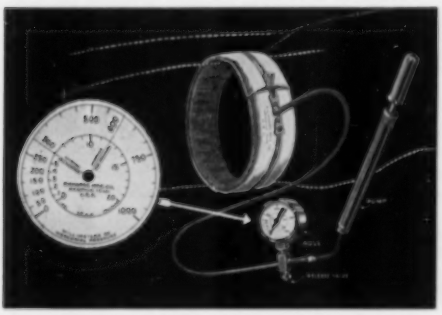
No. 414 PAIR **$10.00**

These "BENDING IRONS" are made of Heat Treated ALUMINUM ALLOY and are designed for

Bending and Forming Bone Plates
Bending and Forming Moore or Blount Plates
Bending and Forming Jewett Nails
Bending and Forming Intramedullary Nails

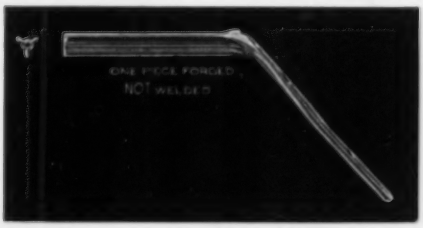
They will not mark, mar or scar bone plates, nails, pins or any other object

CAMPBELL-BOYD PNEUMATIC TOURNIQUET



No. 310 • Large size for leg; gauge and pump. **$35.00**
No. 311 • Medium size for arm; gauge and pump **35.00**
No. 311C • Small size for small arm; gauge and pump **35.00**
No. 311CC • Infant size **35.00**
Set of 4 sizes complete **135.00**

JEWETT NAIL — Stainless SMO
One-Piece Forged



No. 381N **$12.50**
Nail Lengths: 2½", 2¾", 3", 3¼", 3½", 3¾", 4", 4¼" 4½", 5".
Plate Lengths: 3", 4", 5", 6".

Write for
Our Complete Catalog of
Orthopaedic Instruments

RICHARDS MANUFACTURING COMPANY

756-8 Madison Avenue • ***Phone 8-2566*** • **Memphis 7, Tennessee**

THE COMPLETE ORTHOPAEDIC SUPPLY DEPOT

THE *Richards* ELECTRIC

Patent Pending

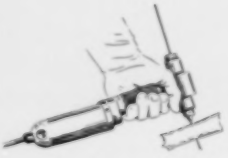
BONE DRILL AND SCREWDRIVER

USED FOR:

- CONTROLLED SPEED DRILLING AND CURETTING
- DRIVING AND REMOVING BONE SCREWS
- DRIVING AND REMOVING HIP SCREWS
- INSERTING STEINMAN PINS AND THREADED PINS
- INSERTING KIRSCHNER WIRES
- MEDULLARY CANAL REAMING
- TROCHANTER REAMING
- ACETABULUM REAMING (FOR PROSTHESIS)
- CRANIAL BURRING
- ROTARY SAWING

Screw Driving and Removing

THE RICHARDS ELECTRIC BONE DRILL is a well-balanced, powerful, yet light weight precision instrument designed to reduce the labor and time element for the surgeon. Various possible uses are illustrated. Easily sterilized by autoclaving. It may be used either with or without the right angle head. The drill motor without the right angle head develops a maximum speed of 1100 RPM with an approximate power rating of 3/8 HP. The drill motor unit is complete with 1/4" chuck. The right angle head is cannulated so that threaded pins or wires can extend through it. A chuck at either end provides both clockwise and counter-clockwise rotation. Powerful gears reduce the speed to 550 RPM maximum in the right angle head, the correct speed for drilling bone. Nearly 3/4 horsepower is developed here even at the lowest speeds. THE RICHARDS BONE DRILL is unconditionally guaranteed for one year against defects in workmanship and material.

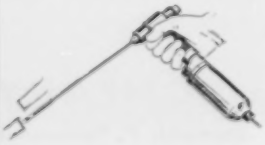


Inserting Steinman Pins and Kirschner Wires

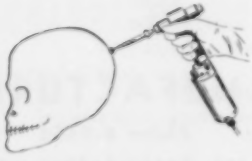
FOR DETAILED INFORMATION, WRITE:

RICHARDS MANUFACTURING CO.

756 MADISON AVE. MEMPHIS TENN.



Intramedullary Reaming



Cranial Burring

Hip Reaming

In answering advertisements, please mention *The Journal of Bone and Joint Surgery.*

for patients with painful "creaky" joints

Pabirin . . . safest of the antirheumatic salicylate-paba combinations

For these reasons: Salicylism does not occur, even with heavy daily requirements. *Low* dosage levels produce *high* blood levels. Acetylsalicylic acid, the most effective of the salicylates, is well-tolerated. Pabirin is sodium- *and* potassium-free. It offsets salicylate depletion of vitamin C by providing a therapeutic amount of 300 mg. in the average daily dose of six capsules. **And highly effective.** . . High blood levels are promptly reached and sustained due to the mutually potentiating action of acetylsalicylic acid and PABA plus the retarding effect of PABA on salicylate excretion. Rapidly disintegrating capsules provide fast absorption and pain relief.

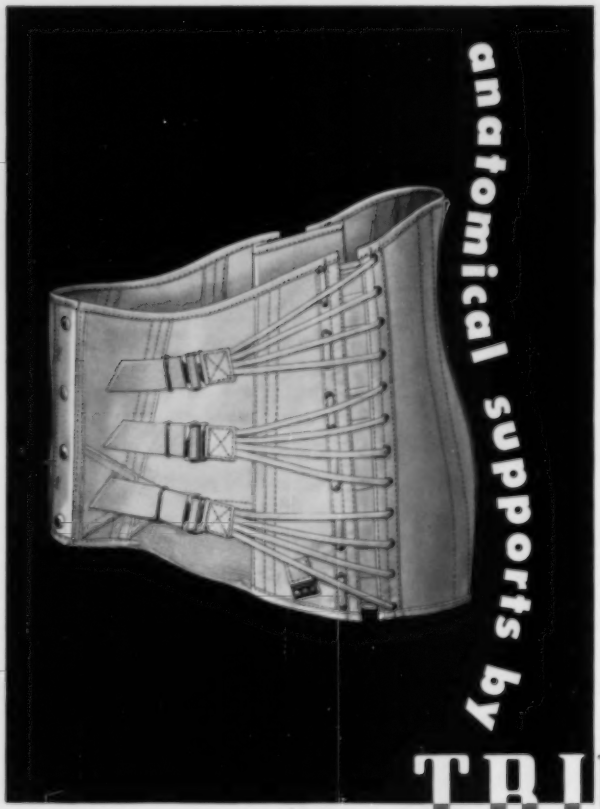
Pabirin is a DORSEY preparation.

Each capsule contains:
Acetylsalicylic acid ..... 5 gr.
Para-aminobenzoic acid ..... 5 gr.
Ascorbic acid ..... 50 mg.
Average dose: 2 to 3 capsules 3 or 4 times daily.
Supplied: In bottles of 100, 500 and 1,000 capsules.

Pabirin®

Smith-Dorsey • Lincoln, Nebraska • A Division of The Wander Company

In answering advertisements, please mention *The Journal of Bone and Joint Surgery.*



THREE pull straps control traction in model 430-EHS lumbo-sacral support pictured . . . two semi-rigid steels. WRITE for "Truform Red Book," the fully illustrated reference catalog of Surgical Supports and Elastic Hosiery.

TRUFORM

Please read this "detail", Doctor . . .
because it's what your favorite **Truform** fitter would tell you, we believe, if he or she visited your office . . .

Truform's educational program offers the finest training in the selection and fitting of *surgical* supports. **Truform** supports are designed on well-understood physiological principles, with a thorough understanding of the supportive or corrective effects to be attained. And there are a wide variety of designs to permit your selection of exactly the correct type to provide maximum therapeutic effect consistent with comfort.

TRUFORM Anatomical Supports are available only from the Ethical Appliance Dealer.

TRUFORM *The Professional Line* ANATOMICAL SUPPORTS

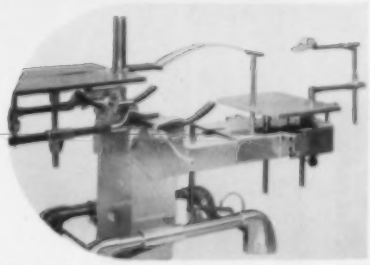
®TRUFORM

anatomical supports
3960 ROSSLYN DR., CINCINNATI 9, OHIO

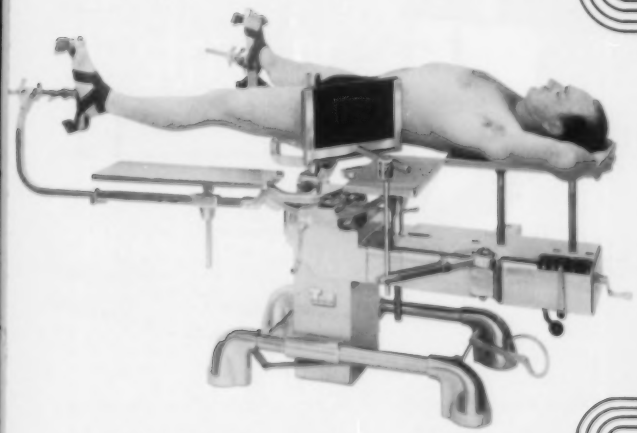
TOWER

ROGER ANDERSON TABLES

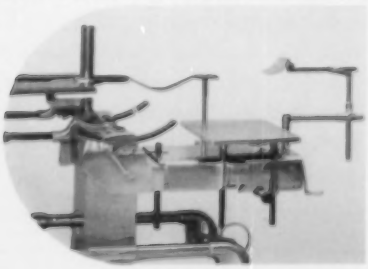
FINEST IN FRACTURE TABLES



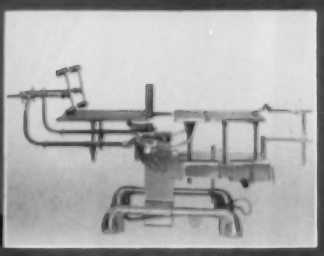
GOLDTHWAITE IRONS — NOTE EASE OF CAST APPLICATION



INTERSCAPULAR SUPPORT — ALSO EXCLUSIVE WITH TOWER



1800



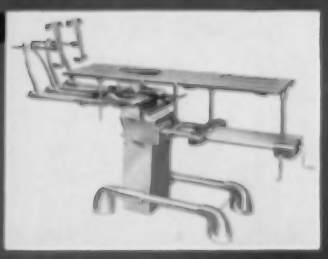
HEAD-END CONTROLS NOW AVAILABLE

Lateral cassette holder swung into place at hip. Exclusive anatomical facilities insure perfect reductions and secure immobilization during surgery, X-ray procedures, or casting to any part of the body.

Note the exclusive, time and money-saving Quic-Tach Foot Straps for quick and easy securing of the feet.

ROGER ANDERSON SPECIALIST MODEL

1700



THE TOWER COMPANY INC.

P. O. BOX 3181, SEATTLE 14, WASHINGTON — FIFTH & STEVENS, GENEVA, ILLINOIS

In remedial exercise therapy

it takes **Both..**

COMPETENT PERSONNEL

plus the

PROPER CLINICAL TOOLS

to insure the desired end results!

The Elgin Exercise Appliance Co. has specifically designed and developed, in a scientific manner, a complete line of progressive resistance exercise equipment to meet the many and varied problems of remedial exercise therapy. This equipment gives the doctor and technician the proper clinical tools with which to administer a great variety of remedial exercises for both the surgical and non-surgical patient. It also provides a wide exercise range, from simple functional exercises to the most highly definitive focal exercises.

WRITE TODAY for available information that will give you a better introduction to this equipment and what it can do for you.

Elgin EXERCISE APPLIANCE CO.

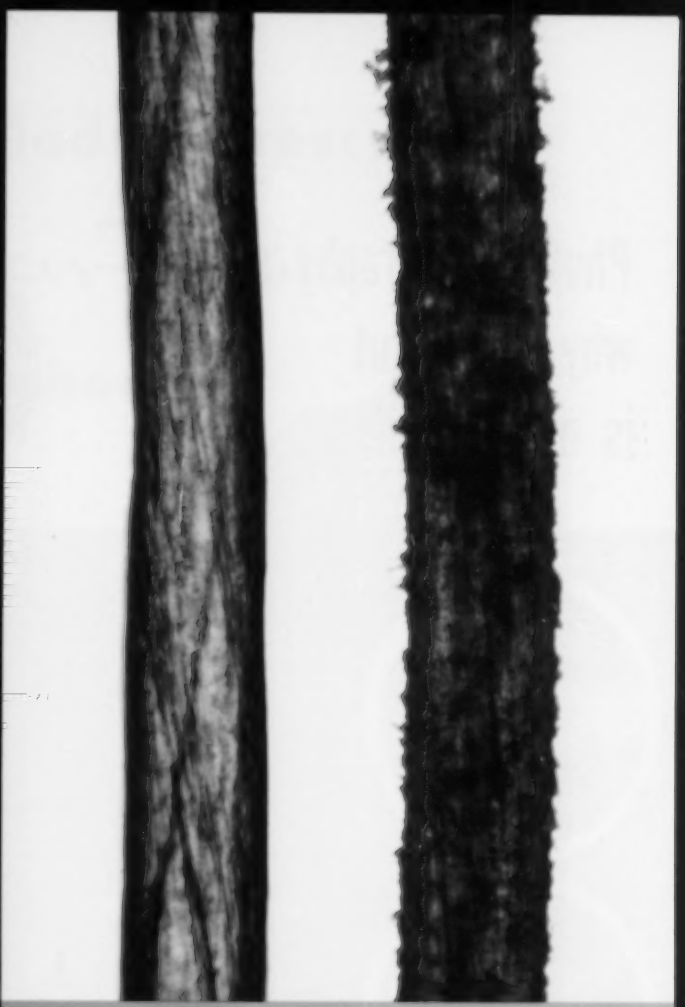
P. O. BOX 132, DEPT. A • ELGIN, ILLINOIS

Research shows why D & G gut is stronger

PHOTOMICROGRAPHY SEES WHAT THE HAND CANNOT FEEL

Photomicrographs (unretouched) by E. J. Thomas, Stamford Laboratory of the Research Division of the American Cyanamid Company, Stamford, Conn.

Method used: dark field, transmitted bright field illumination, 120 x. Material used: medium chromic gut, size 5-0.



D & G gut

Photomicrograph shows the smooth surface of D & G SURGICAL GUT, with practically no fraying or roughness. *Reason:* Carefully controlled slitting of plies plus uniform twisting provides a smooth, well-bonded strand. No need to grind it to size. Gentle polishing gave the matte finish. *Result:* the full natural strength of each gut ribbon (ply) is preserved; the strand is not frayed by grinding.

Another leading gut

Photomicrograph reveals rough, frayed surface of another leading brand of gut. This has been ground to size. Gut processed in this way appears very uniform in diameter to the naked eye. But the photomicroscope reveals serious imperfections which may cause fraying and loss of strength when the knot is tied.

see exhibit on next page

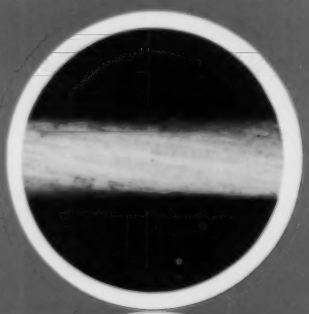
SUTURES AND OTHER D&G SURGICAL SPECIALTIES

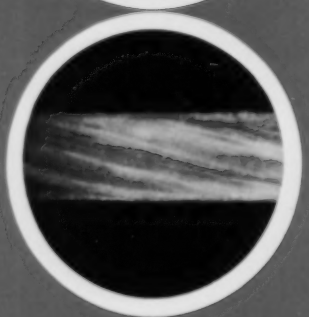
DAVIS & GECK INC.

A UNIT OF AMERICAN Cyanamid COMPANY

DANBURY, CONNECTICUT

Photomicrography shows why D & G gut is more flexible





D & G GUT

Firm, even cohesion of plies is apparent in this photomicrograph of a D & G SURGICAL GUT suture.
Reason: plies were twisted into a strand before suture was chromicized. Natural cohesive forces of moist untreated collagen firmly bond the plies together and hold the twist.
Result: under stress, plies of the suture hold together. The D & G gut is more flexible and knot strength is greater.

ANOTHER LEADING GUT

Photomicrograph detects separate and distinct plies in a strand of another leading brand of surgical gut. Here each ply was chromicized before they were twisted into suture strands. Such "ribbon chromicizing" hardens the surface of each ply, decreasing the natural bonding action, lowering the flexibility and tensile strength of the suture.

Photomicrographs (unretouched) by E. J. Thomas, Stamford Laboratory of the Research Division of the American Cyanamid Company, Stamford, Conn.

Method used: dark field, reflected illumination, focus on crest of surface, 32 x. Material used: medium chromic gut, size 00.

see exhibit on previous page

SUTURES AND OTHER D&G® SURGICAL SPECIALTIES

DAVIS & GECK INC.

A UNIT OF AMERICAN Cyanamid COMPANY

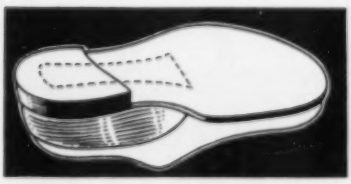
DANBURY, CONNECTICUT

You'll be glad to prescribe

Alden-Pedic

shoes

Alden-Pedic lasts are designed to accommodate your prescribed corrections and insertions. Extreme sizes stocked. Many styles available for men and boys. Top quality only.



Alden-Pedic

SCIENTIFIC CONSTRUCTION

- Long inside counter
- Heavy gauge ribbed steel shank
- Right and left angled heels, long inside
- Patented bottom filler prevents insole lumping

Alden-Pedic lasts and shoes have been scientifically designed and tested to accommodate specific and general degrees of foot disabilities. Doctors who become familiar with the functional merit of this program will be glad to prescribe these shoes as a foundation in the treatment and correction of foot disabilities. We do not claim that these shoes will correct abnormal foot conditions, but they will provide the types of basic footwear necessary as a foundation in aiding foot trouble and in offering foot comfort. We know you will be glad to recommend them.

FOR BOOKLET AND NAME OF NEAREST DEALER, WRITE

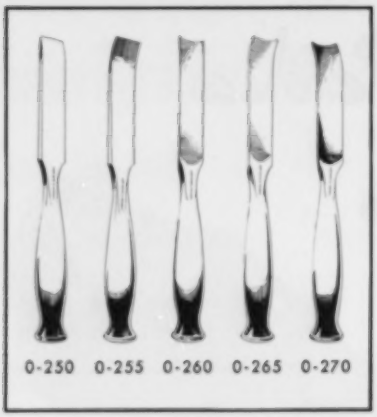
C. H. ALDEN SHOE COMPANY

BROCKTON, MASSACHUSETTS

Custom Bootmakers Since 1884

In answering advertisements, please mention *The Journal of Bone and Joint Surgery.*

SMITH-PETERSEN OSTEOTOMES and GOUGES



0-250 0-255 0-260 0-265 0-270

0-250 SMITH-PETERSEN OSTEOTOME—straight, 8", sizes ¼", ⅜", ½", ⅝", ¾", 1" and 1¼". Stainless Steel.

0-255 SMITH-PETERSEN OSTEOTOME—curved, 8", sizes ¼", ⅜", ½", ⅝", ¾", 1" and 1¼". Stainless Steel.

0-260 SMITH-PETERSEN GOUGE—straight, 8", sizes ⅜", 9/16", ¾" and 1". Stainless Steel.

0-265 SMITH-PETERSEN GOUGE—curved, 8", sizes ⅜", 9/16", ¾" and 1". Stainless Steel.

0-270 SMITH-PETERSEN GOUGE—reverse curved, 8", sizes ⅜", 9/16", ¾" and 1". Stainless Steel.

A NEW STAINLESS STEEL CASE TO HOLD SMITH-PETERSEN OSTEOTOMES and GOUGES

0-295 Open

CASE 0-295—holds seven Smith-Petersen Osteotomes.

CASE 0-296—holds seven Smith-Petersen Gouges.

CASE 0-297—holds a combination of seven Osteotomes and Gouges.

Cutting edges are protected at all times. Complete unit may be autoclaved.

0-295 Closed

Specify Width of Gouges and Osteotomes When Ordering

ESTABLISHED 1834

Codman & Shurtleff, Inc.

MAKERS OF SURGEONS' INSTRUMENTS

104 BROOKLINE AVENUE BOSTON 15, MASSACHUSETTS

In answering advertisements, please mention *The Journal of Bone and Joint Surgery*.

New TENSOR adjusts itself to the swelling

maintains proper support—
without constriction—throughout every
stage of swelling

When swelling goes up . . . Tensor elastic bandage goes with it. When swelling goes down . . . Tensor goes down, too.

Tensor is made with Live Rubber Threads which provide *lasting* elasticity. It retains its positive stretch and snap-back long after ordinary bandages are limp and lifeless.

Because of this, Tensor elastic bandage is able to give and take with the swelling. Never constricts. Never binds.

And with Tensor, doctor, you can bandage for low pressures as easily as higher pressures. Tensor elastic bandage holds whatever pressure *you* apply.

Heat won't affect its elasticity, either. Tensor can be washed and dried in automatic machines—time after time—without losing its "snap".

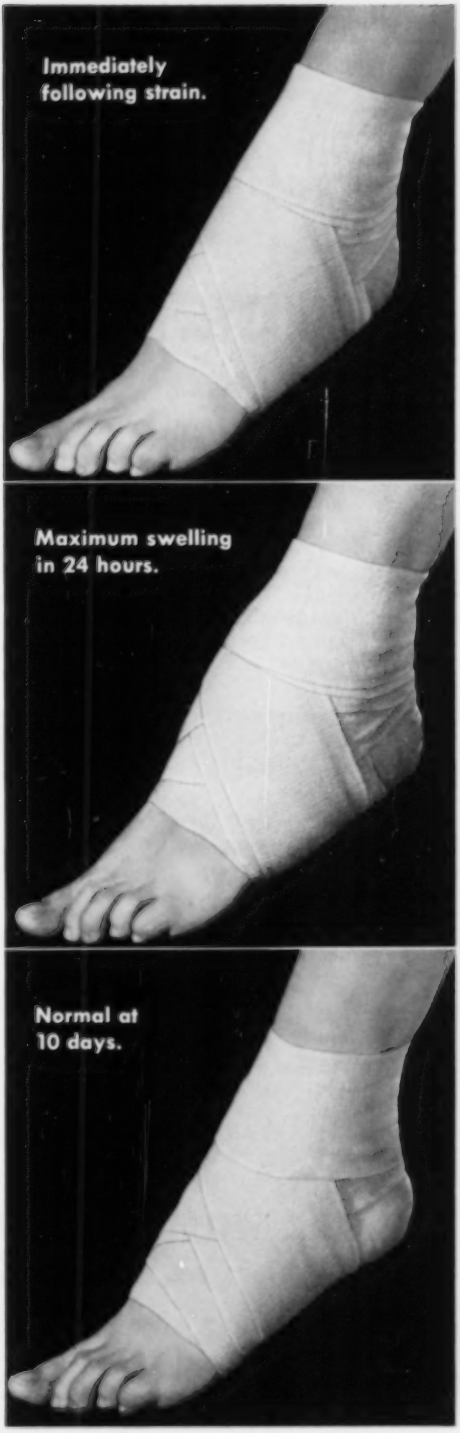
Shouldn't your patients have the advantages of TENSOR elastic bandage!

NEW FOR DOCTORS—Save 32%
when you order in bulk

New TENSOR®
ELASTIC BANDAGE

Woven with Heat-Resistant
live rubber threads

BAUER & BLACK
Division of The Kendall Company
309 West Jackson Blvd., Chicago 6, Illinois



FRACTURES IN CHILDREN

Walter P. Blount, M.D.

Chairman, Orthopaedic Section
Milwaukee Children's Hospital

270 pages

311 figs.

$9.50

Its basis—
wide clinical experience

OVER 20 YEARS practical experience in the field has produced the author's thesis that fractures in children must be treated differently than fractures in adults.

Emphasis is on the illustrations as the most graphic method of telling the story. The author uses roentgenograms reproduced as positives, medical drawings of fractures and their treatments and photographs of patients, in a very effective illustration program.

The suggested method of treatment of children's fractures in the book stresses careful diagnosis followed by simplified treatment. Growth factors are recognized but not overemphasized.

Chapters include injuries of shoulder girdle, humeral shaft, elbow, arm, hand, femur, knee, leg, angle, foot, ribs, sternum, pelvis, spine, face, skull, open and pathologic fractures.

FRACTURES IN CHILDREN helps make physicians aware of a need and, in so doing, answers that need in this valuable work for all those concerned with children's fractures.

THE WILLIAMS & WILKINS COMPANY

Mt. Royal and Guilford Avenues

Baltimore 2, Maryland

FOR SELF-ADMINISTERED INHALATION ANALGESIA

ACCEPTED COUNCIL ON PHARMACY AND CHEMISTRY AMERICAN MEDICAL ASSOCIATION

ACCEPTED COUNCIL ON PHYSICAL MEDICINE AND REHABILITATION AMERICAN MEDICAL ASSOCIATION

"Trilene"®

Brand of trichloroethylene U.S.P. (Blue)

"Duke"® University Inhaler

No. 3160 Model-M

in obstetrics and minor surgery

notably safe and effective

"Trilene," self administered with the "Duke" University Inhaler, under proper medical supervision, provides highly effective analgesia with a relatively wide margin of safety. Induction is usually smooth and rapid with minimum or no loss of consciousness. If unconsciousness occurs, inhalation is automatically interrupted. Nausea and vomiting seldom occur. Recovery is rapid.

"Trilene" is now accepted by the Council on Pharmacy and Chemistry of the American Medical Association.

convenience of administration

The "Duke" University Inhaler (Model-M) is specially designed for economy, facility of handling, and ready control of vapor concentration. The patient treated on an ambulatory basis in the physician's office or the hospital can usually leave within 15 to 30 minutes.

The "Duke" University Inhaler is now accepted by the Council on Physical Medicine and Rehabilitation of the American Medical Association.

"Trilene" alone is recommended only for analgesia, not for anesthesia nor for the induction of anesthesia. When using "Trilene" in conjunction with anesthetic agents (as an analgesic adjunct), standard machines may be employed provided they are adjusted so that "Trilene" *is not used in a closed circuit with soda lime.* Epinephrine is contraindicated when "Trilene" is administered.

"Trilene" is available in 300 cc. containers, 15 cc. tubes, and 6 cc. ampuls.

Ayerst Laboratories make "Trilene" available in the United States by arrangement with Imperial Chemical (Pharmaceuticals) Limited.

Ayerst Laboratories • New York, N. Y. • Montreal, Canada

Ayerst

5515

SIZES
INFANTS'
1½ to 8
CHILDREN'S
8½ to 11

SABEL'S
CLUB FOOT
TRADE MARK
SHOE
REG. U.S. PAT. OFF.

SIZES
MISSES' & YOUTHS'
11½ to 2
BIG BOYS'
2½ to 6

PATENTED

RIGHT

LEFT

Dotted line on cut shows outline of normal shoe. Shoe cut shows abnormal outward swing of Sabel's Club Foot Shoe

Sabel's Club Foot Shoes are for use after the doctor has over-corrected the position of the club foot. The outward swing of this shoe braced by the long outside counter will tend to keep the position the doctor desires.

Sabel's Surgical Shoes are carried in pattern and leather matching the Club Foot Shoes so that where required, even in split sizes, they can be fitted to the other foot.

I. SABEL, Inc.

1207 Chestnut Street Philadelphia 7, Pa.

WRITE FOR NAMES OF DEALERS WHO CAN SUPPLY SABEL'S CLUB FOOT SHOES
SEND FOR BOOKLET WITH COMPLETE DETAILS

Made Exclusively by

THOMPSON BROS. SHOE CO., Brockton, Mass.

now!

for truly symmetrical sockets, use

CO-AXIAL SOCKET REAMERS

with the interchangeable shanks

don't scrape... don't chisel... don't grind... don't try to improvise a truly symmetrical socket with instruments that *can't give you that result.*

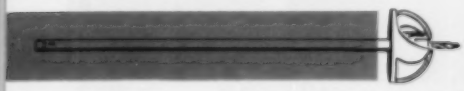
Only

TOWER CO-AXIAL SOCKET REAMERS ARE CORRECTLY DESIGNED TO GIVE YOU

Co-axial centering of shank • True symmetry • Precision cutting of cartilage, cortical and cancellous bone • Removal of cuttings • No clogging
All reamer sizes — 39, 41, 43, 45, 47, 49, 51, 53, 55 mm. diameter

TECHNIC—Dislocate femur and displace posteriorally. Position reaming head in acetabulum—insert shank from below (through tissue and muscles along the normal femoral-neck line) and engage head.

NOTE: If reamer tends to "wander" because of sloping acetabulum, use shank with drill extension. Projecting drill tip maintains location.



SPECIAL GROUP PRICE
Any three cutting heads plus two shanks, plus brace —$190.00 complete.

Send for literature and prices

THE TOWER COMPANY, INC.

P. O. Box 3181, Seattle 14, Washington

Fifth and Stevens, Geneva, Illinois

FOR GREATER STRENGTH AND SAFETY—

DEMAND GENUINE **NEUFELD NAILS** *and* **SCREWS**

—IN **NEUTRILIUM®**

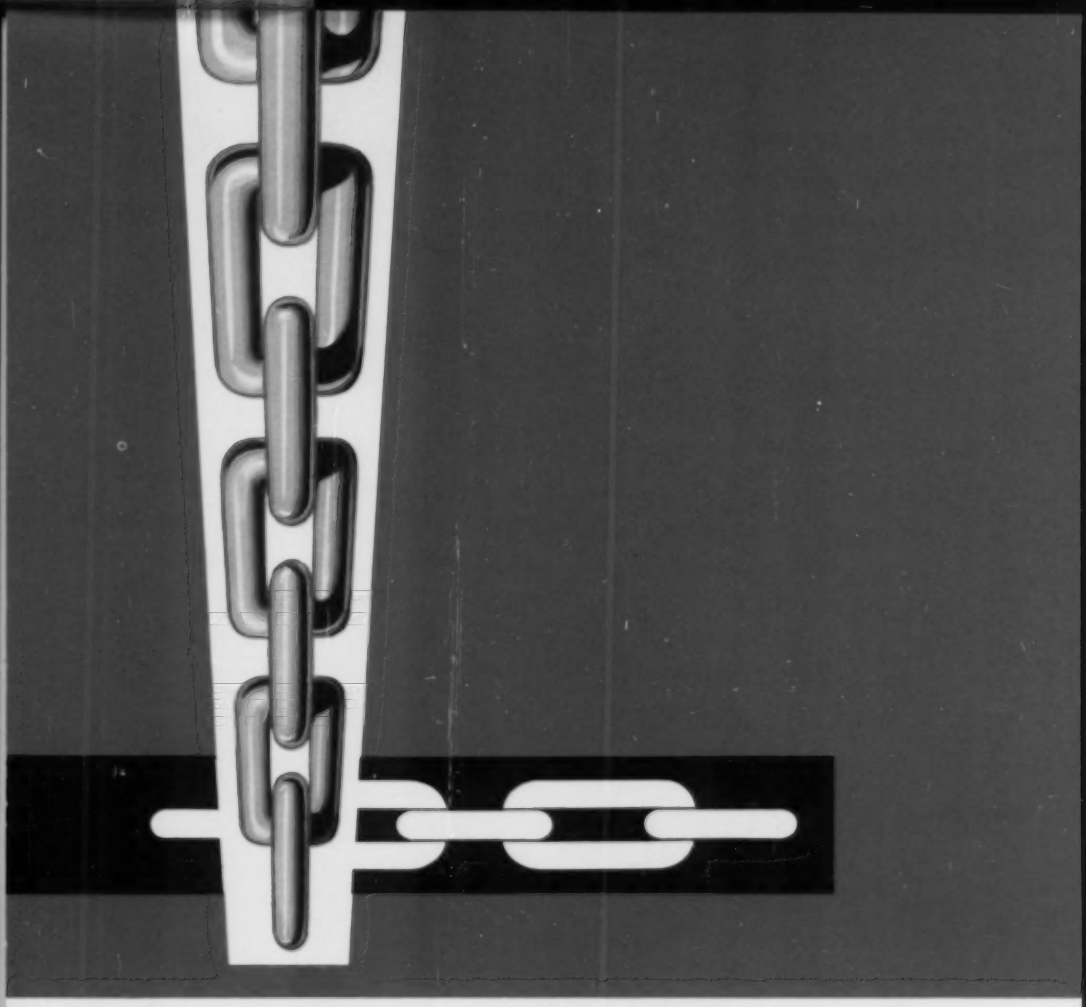
NEUTRILIUM® is the most non-corrosive metal known to science. Its proven super-strength lends an assurance of permanence to internal fixation of the trochanteric area. This neutral, non-magnetic, homogenetic alloy is entirely inert and therefore compatible with human bone or tissue, remaining unaffected by body chemistry.

NEUFELD BONE SCREWS — of *NEUTRILIUM®* — are cold forged and, unlike other metals, appear to be unbreakable under maximum human pressures. Heads will not twist off during application or in actual use.

GENUINE NEUFELD NAILS and SCREWS — of *NEUTRILIUM®* — made only by MEDICAL RESEARCH SPECIALTIES, Loma Linda, California, are sold nationally by leading surgical and orthopaedic supply dealers.

NEUTRILIUM® is a registered Trade Name of Medical Research Specialties.

NEUFELD FEMORAL NAIL PLATE
Used for internal fixation of intertrochanteric and subtrochanteric fractures.
Write for descriptive literature
MEDICAL RESEARCH SPECIALTIES
Loma Linda, California



adrenosem®

Salicylate

(brand of carbazochrome salicylate)

THE MISSING LINK IN THE CONTROL OF BLEEDING

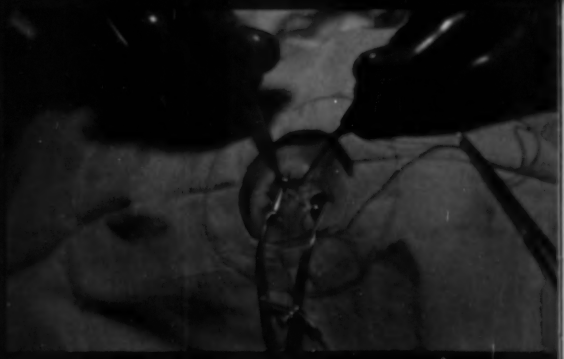
PREOPERATIVELY • where oozing and seepage from a vascular bed is anticipated

POSTOPERATIVELY • to prevent seepage and hemorrhage

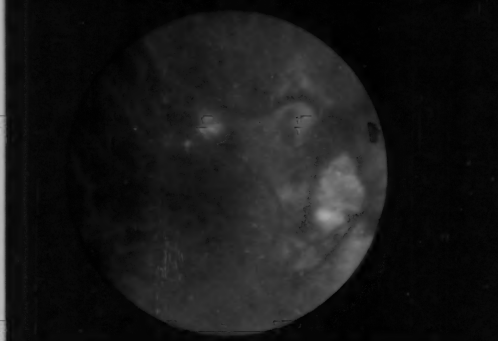
TONSILLECTOMY-ADENOIDECTOMY • RETINAL HEMORRHAGE • EPISTAXIS

DENTAL SURGERY • HEMATURIA

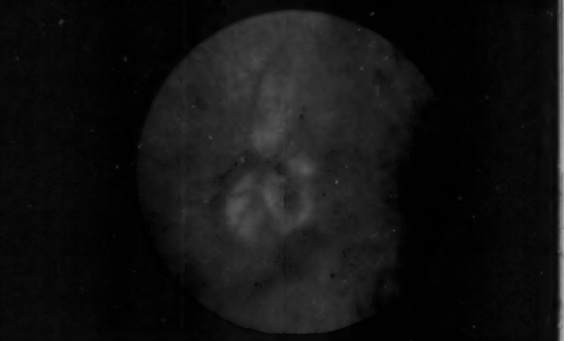
Welling up of blood upon incision of lid and conjunctiva, common in ophthalmic procedures, hampers surgery.



Minimal bleeding after Adrenosem therapy facilitates surgery and promotes healing.

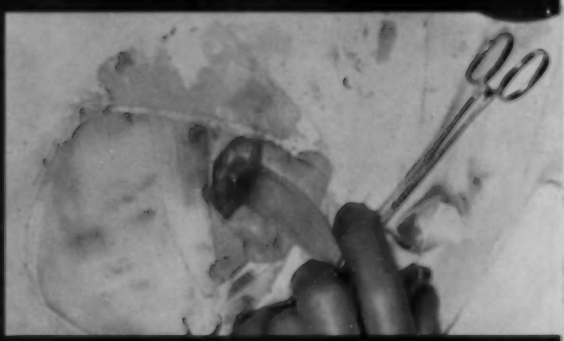


Anticipation of recurrent hemorrhage and visual defect is high in hypertensive patients.



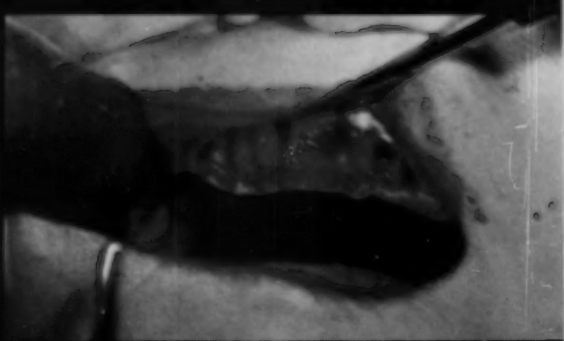
After Adrenosem therapy. Note exudative areas. Maintenance therapy checks further hemorrhage.

Mastoidectomy with a bloody field obscures view, requires frequent suctioning.



After Adrenosem therapy. Note clearer operative field with minimized bleeding.

Multiple extraction without Adrenosem. Note seepage. Frequent suctioning is required.



After Adrenosem therapy. Note clearer field. Minimal bleeding facilitates surgery and promotes healing.

Adrenosem®

Salicylate *(brand of carbazochrome salicylate)*

Adrenosem is specific for conditions characterized by increased capillary permeability allowing oozing and seepage bleeding. To prevent seepage bleeding due to capillary permeability it is necessary to maintain tone of the capillary wall. This is supported by Pappenheimer's[1] work on capillaries. In cases of capillary permeability it is postulated that the connective material between the cells, which form the capillary wall, has lost its tone and allows the erythrocytes to pass through.

To confirm the action of Adrenosem in establishing capillary integrity the cheek pouch of a hamster was irritated with snake venom, which has the property of making the capillaries more permeable.[2] A great many petechiae appeared on the surface and a 500 X magnification showed the capillaries with extravasation of erythrocytes. Another animal was treated with Adrenosem, and 30 minutes later, the same amount of snake venom was used to irritate the cheek pouch. Microphotographs of the same 500 X magnification show the intact capillary walls and the actual blood cells coursing through the capillaries, without signs of escaping erythrocytes.

Fig. 1—*Trauma from snake venom produces hemoconcentration and stasis, indicative of altered vascular permeability.*

Fig. 2—*Trauma does not produce petechiae following Adrenosem injection.*

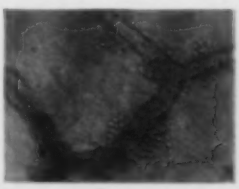


Fig. 1

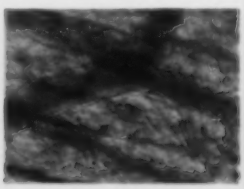


Fig. 2

Action

A systemic hemostat, Adrenosem restores capillary integrity by maintaining tone of intercellular tissue in the capillary wall. Adrenosem is unlike any hemostat available to medicine.[3,4] It does not interfere in any way with the blood clotting mechanism or its component parts. There is no sympathomimetic action and the blood pressure, cardiac rate and volume are not affected. Adrenosem may be administered simultaneously with any type of anesthetic, anticoagulant or vitamin K and heparin. Adrenosem will not interfere with the action of these agents.

THE S. E. MASSENGILL COMPANY

BRISTOL, TENNESSEE • NEW YORK • KANSAS CITY • SAN FRANCISCO

Adrenosem®

Salicylate (*brand of carbazochrome salicylate*)

BIBLIOGRAPHY

While the hemostasic action of epinephrine and related compounds has been recognized for a long time, certain characteristics limited their usefulness. A product of the metabolism of epinephrine seemed to offer the most promise. Given the name, Adrenochrome, this compound was studied extensively in both European and American centers. The handicap to wide use of Adrenochrome was its instability, so efforts were directed to find a stable modification that would retain the physiological activity. The answer to this proved to be the monosemicarbazone of Adrenochrome. Further research demonstrated that this compound could be made soluble enough to be practicable as an injectable solution, by transforming it to a sodium salicylate complex. This process has made possible Adrenosem Salicylate, a potent therapeutic agent which fills an important need in medicine.

1 *Pappenheimer, John R.: Passage of molecules through capillary walls, Physiol. Rev. 33:387-423, 1953.*

2 *Fulton, M. D., Department of Biology, Boston University: Personal communication, 1954.*

3 *Sherber, Daniel A.: Adrenochrome complex in the control of bleeding, Am. J. Surg. 86:331-335, 1953.*

4 *Roskam, J.: Arrest of Bleeding, Chas. C. Thomas, Publisher, Springfield, Ill., 1954*

5 *Peele, J. G.: Adrenosem in the control of hemorrhage from the nose and throat (in press).*

6 *Bourgoyne, J. R. and Riddle, A. C., School of Dentistry, University of Tennessee: Personal communication, 1954.*

SUPPLY

Ampuls, 5 mg., 1 cc.: packages of 5.

Tablets, 1 mg. (s. c. orange): bottles of 50.

Tablets, 2.5 mg. (s. c. yellow): bottles of 50.

Syrup, 2.5 mg. to each 5 cc. (1 teaspoonful): 4 oz. bottles.

DOSAGE

• preoperatively to control oozing during surgery and provide clearer operative field: one to two ampuls (5 to 10 mg.) every two hours prior to surgery for two doses.

• postoperatively to prevent hemorrhage and check oozing:
one to two ampuls (5 to 10 mg.) every two hours until there is no indication of undue bleeding. To maintain control, one ampul may be administered every three hours or 1 to 5 mg. orally t.i.d.

• to control active bleeding:
one ampul (5 mg.) every two hours until bleeding is controlled; frequency of dose may then be diminished.

• to control mild, low-grade bleeding:
one ampul (5 mg.) every three or four hours until bleeding is controlled; then 1 to 5 mg. orally four to five times daily until bleeding ceases.

• maintenance dosage to prevent bleeding in conditions where small vessel integrity may be impaired:
1 to 5 mg. orally t.i.d.; if bleeding ensues, dosage may be increased 1 to 5 mg. orally every three or four hours; if bleeding persists, oral dosage should be supplemented with one ampul (5 mg.) daily.

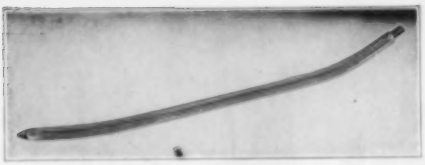
• pediatric dosage:
up to four years of age—1 mg. intramuscularly or orally with same frequency as for adults, until bleeding is controlled. From four to twelve years of age—one-half the adult dosage as indicated.

THE S. E. MASSENGILL COMPANY

BRISTOL, TENNESSEE • NEW YORK • KANSAS CITY • SAN FRANCISCO

Detailed literature on request

LOTTES TIBIAL NAIL



LOTTES TRIFLANGE TIBIAL NAIL
Tibial Nail diameters: 5/16" and 3/8"

DRIVER AND EXTRACTOR

18-8 SMo Stainless Steel nail made in ½ inch lengths from 9 to 14½ inches.

The triflange nail is also available for femur, humerus, radius, and ulna.

The driver and extractor can be used with any of the triflange nails.

COMPOUND FRACTURE WHICH WAS DEBRIDED, CLOSED, AND PLACED IN CAST ON ADMISSION

RESULT THREE MONTHS AFTER PRIMARY HEALING OF WOUND AND CLOSED NAILING

For further information, please write to

CHAS. A. SCHMIDT SURG. INST. CO., ST. LOUIS 8, MISSOURI
3689 Olive Street

In answering advertisements, please mention *The Journal of Bone and Joint Surgery*.

It's Portable!

Jacuzzi WHIRLPOOL BATH

Model J-300
PATENT
PENDING

Doubles usage... halves the cost

Versatile and economical . . . one unit serves all therapy tanks or bathtubs.

Adaptable. Can be placed in tank wherever needed for most beneficial effect. No clamps or bolting necessary.

Effective: Its ⅓ h.p. motor puts out forty-five gallons of churning, aerated water per minute! Force and direction of flow quickly, easily adjustable to patients' specific needs. No maintenance or extra plumbing required. Compact. Weighs only 25 lbs.

Proven: Developed and tested through seven years of research under supervision of physicians.

Safe: Accepted and fully approved for professional use by Underwriters Laboratories.

Jacuzzi WHIRLPOOL BATH

JACUZZI BROS. INC.
Hydrotherapy Division
1456 San Pablo Avenue • Berkeley 2 • California

Write for illustrated bulletin giving full details.

Made by the originators of the injector-type water system

Immobilize - Brace - Rest

with CAMP

DORSOLUMBAR SUPPORTS

Camp Dorsolumbar Supports are especially adaptable for use after plaster casts or orthopedic braces have been removed. In many cases they may be used in place of heavier braces resulting in greater patient comfort. Additional steels may be added to meet the exact requirements of the diagnosis. Shaping of steels for precise fit can be accomplished by hand. Camp Dorsolumbar Supports are carried in stock by Authorized Camp dealers. A complete style and size range enables each patient to be exactly fitted without waiting for "special" manufacture. Their lower cost, and comfort encourage patient use.

S. H. CAMP and COMPANY
JACKSON, MICHIGAN
World's Largest Manufacturer of Anatomical Supports
OFFICES: 200 Madison Avenue, New York; Merchandise Mart, Chicago
FACTORIES: Windsor, Ontario; London, England

TO MAKE PRESCRIBING OF CAMP SUPPORTS EASIER WRITE FOR YOUR COPY OF THE PHYSICIANS AND SURGEONS REFERENCE BOOK FOR ADDITIONAL DETAILS ON THE COMPLETE CAMP LINE.

In answering advertisements, please mention *The Journal of Bone and Joint Surgery.*

★ ★ ★ ★ ★

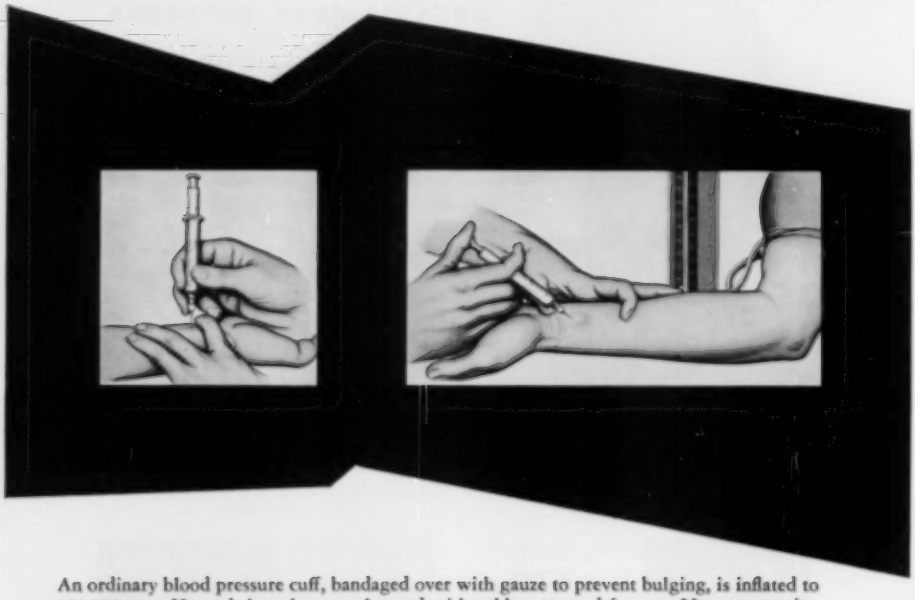
LATEST REPORT

RELATIVELY SAFE AND SIMPLE TECHNIC

Combined Use of Local Anesthesia and Tourniquet in SURGERY OF THE HAND

Use of NOVOCAIN in conjunction with a tourniquet in hand surgery eliminates the need for general anesthesia in many cases, maintains voluntary motor power, produces a clear operative field and eliminates the trauma of repeated spongings.*

*Walsh, A.C.: *Canad. Med. Assn. Jour.* 70:539, May, 1954.



An ordinary blood pressure cuff, bandaged over with gauze to prevent bulging, is inflated to 250-300 mm. Hg and the tubes are clamped with rubber covered forceps. No preoperative sedation or analgesia is required if tourniquet remains in place for less than 20 minutes.

To block the nerve trunk, a 25 gage x ¾ inch needle is inserted at a right angle over the nerve trunk. After the patient is instructed to report tingling along course of nerve, a quick short jab is made towards the trunk. As soon as paresthesias are reported, from 1 to 2 cc. of 2% NOVOCAIN solution are injected directly into the nerve trunk. The needle is withdrawn slightly and 2 or 3 cc. are injected around the nerve. Anesthesia takes full effect within from 5 to 10 minutes.

NOVOCAIN® *Solutions in various concentrations with and without vasoconstrictors. Also tablets, crystals and powder.*

Winthrop-Stearns INC. WINTHROP New York 18, N.Y. • Windsor, Ont.

Novocain (pioneer brand of procaine hydrochloride), trademark reg. U. S. Pat. Off.

In answering advertisements, please mention *The Journal of Bone and Joint Surgery.*

OVER 90% OF HANGER SUCTION SOCKET CASES SUCCESSFUL

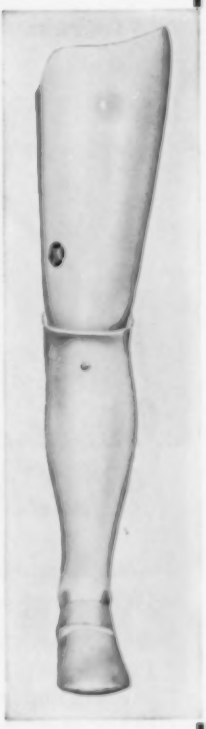
THE Suction Socket Prosthesis has been one of the most important prosthetic developments in recent years. Based on entirely new conceptions of design, it is secured solely by muscular and suction action, and eliminates the hip joint and all belts and straps. With this prosthesis the wearer enjoys greater comfort, control, and utility than ever before possible.

We attribute our proven record of 90% successful Suction Socket applications to: ONE, careful examination, since not all amputations are suited to this type of prosthesis; and TWO, correct fitting, in order to retain the suction action yet avoid discomfort.

HANGER clients are examined and fitted by "Certified Suction Socket Fitters." These Fitters are certified after examination by a Certification Board composed of representatives of the industry and orthopaedic surgeons.

HANGER has been, and is today, a leader in the field of Suction Socket Prosthetics. We took an active part in the basic research with the Veterans' Administration, the Committee on Artificial Limbs of the National Research Council, and the Surgeons General of the Army and the Navy.

HANGER today offers professional Suction Socket service to amputees and doctors throughout the country. We have more than 50 Certified Suction Socket Fitters in our many offices in key cities throughout the United States (see list below)—MORE THAN ANY OTHER PROSTHETICS MANUFACTURER. We welcome the opportunity to furnish appliances to surgeons' prescriptions, and to render any service desired.



Hanger PROSTHESES

ATLANTA 1, GA.
BALTIMORE 1, MD.
BIRMINGHAM 1, ALA.
BOSTON 16, MASS.
CHARLESTON 2, W. VA.
CHARLOTTE 2, N. C.
CHATTANOOGA, TENN.
CHICAGO 5, ILL.
CINCINNATI 2, OHIO
COLUMBIA 5, S. C.
COLUMBUS 8, OHIO
DALLAS 1, TEXAS
EVANSVILLE, IND.
INDIANAPOLIS 2, IND.
JACKSONVILLE, FLA.
KNOXVILLE, TENN.
MEMPHIS, TENN.
MIAMI 37, FLA.
MOBILE, ALA.
MONTGOMERY, ALA.
NASHVILLE, TENN.
NEW ORLEANS 19, LA.
NEW YORK 11, N. Y.
OKLAHOMA CITY 3, OKLA.
PHILADELPHIA 7, PA.
PITTSBURGH 30, PA.
RALEIGH, N. C.
RICHMOND 19, VA.
ROANOKE 12, VA.
ST. LOUIS 3, MO.
SHREVEPORT, LA.
TAMPA 2, FLA.
TOLEDO, OHIO
WASHINGTON 13, D. C.
WILKES-BARRE, PA.

In answering advertisements, please mention *The Journal of Bone and Joint Surgery.*

Imitation . . . A Great Compliment, But Medullary Pins Are Serious Business!

To safeguard the quality of the Rush Pin, — that is why BERIVON® was born.

We realize that the implantation of metal in the marrow cavity of a patient's bone is serious business. That is why we are "fussy" about the Rush Pin. Its metal must be of the best quality and of optimum temper and its features must be perfectly executed by hand. The metal must not be heated in this process and it must be electropolished. There is no place for "second best." That is why no one but Berivon makes

The RUSH MEDULLARY PIN

Patent No. 76,552

THE BERIVON Company
P.O. BOX 1851
Meridian, Miss.

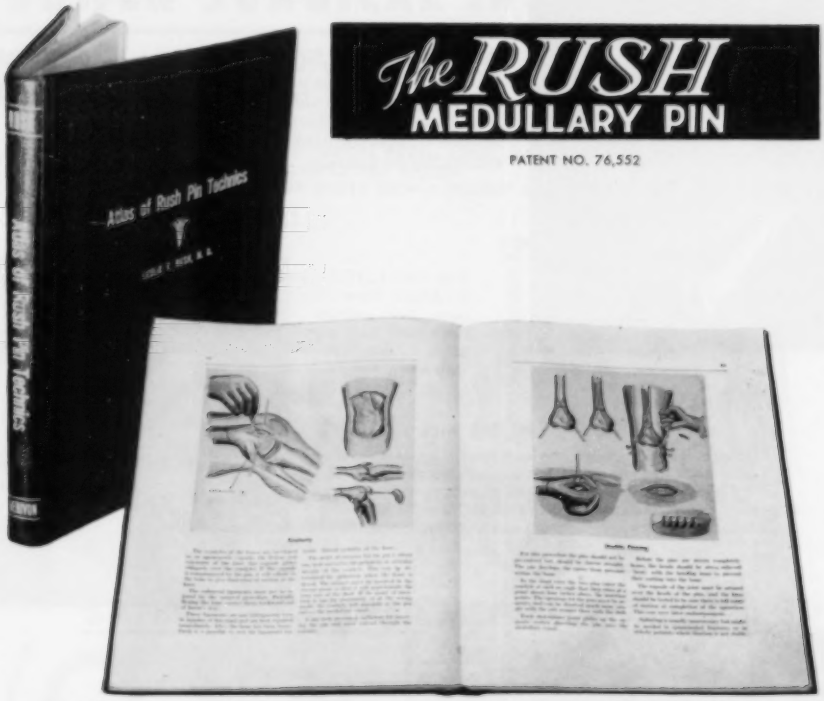
EVERY GENUINE RUSH PIN BEARS THE TRADEMARK **BERIVON** ®

In answering advertisements, please mention *The Journal of Bone and Joint Surgery.*

Companion to

The RUSH MEDULLARY PIN

PATENT NO. 76,552



ATLAS OF RUSH PIN TECHNICS

by **LESLIE V. RUSH, M.D.**

A new system of dynamic fracture fixation, concisely explained in picture form. Pages designed for easy readability without index. Technics presented in progressive steps.

Three Sections: 1. **Dynamics, stability of fixation and general considerations.**
2. **Lower extremity technics.**
3. **Upper extremity technics.**

More than 200 pages. Many more than 1000 illustrations. Ready about June. Price $10.00.

Order Now from

THE BERIVON Company
P. O. BOX 1851
Meridian, Miss.

In answering advertisements, please mention *The Journal of Bone and Joint Surgery.*

*A dynamic approach to better health for the aging patient**

IN THE 40's AND 50's

"disease or body change is lurking in the background"† even though the individual may feel in good health. In this age group "Mediatric"* will help prevent premature atrophic changes due to waning sex hormone function and inadequate nutrition.

IN THE 60's AND 70's

involutional changes become increasingly apparent as the body loses its ability to resist environmental stress. "Mediatric"* will aid the aging economy cope more successfully with three important stressors: gonadal hormone imbalance, dietary insufficiency, and emotional instability.

IN THE 70's AND 80's

functional impairment is at its peak and, in most cases, is the end result of progressive disorders which had their onset in the forties. Patients treated with "Mediatric"* have responded with increased physical vigor, improved muscle tone, and better emotional balance.

†Kountz, W. B.: J.A.M.A. *153*:777 (Oct. 31) 1953.

* "MEDIATRIC"®

Steroid-nutritional compound

STEROIDS . . . to counteract declining sex hormone function
NUTRITIONAL SUPPLEMENTS . . . to meet the needs of the aging patient
A MILD ANTIDEPRESSANT . . . to promote a brighter mental outlook

Ayerst

Ayerst Laboratories
New York, N. Y., Montreal, Canada

Capsules, No. 252 — bottles of 30, 100, and 1,000.
Liquid, No. 910 — bottles of 16 fluidounces and 1 gallon.

5416

Average dosage, 1 capsule or 3 teaspoonfuls of liquid, daily.

Proved in Practice . . .

BOWEN SURGICAL INSTRUMENTS

Many Superior Features in Bowen Chisels, Gouges, and Osteotomes

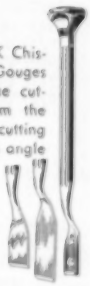
Hand-Forged of 440-C Stainless Steel

- HARDENED AND TEMPERED TO RIGID SPECIFICATIONS
- KEEN CUTTING EDGE WITH PRECISE BEVEL, LONG SLENDER BLADE
- LONG HANDLES FOR UNOBSTRUCTED VISION
- THUMB REST HANDLES FOR BETTER GRIP • PERFECT BALANCE

BOWEN GOUGES are of distinctive design and style. In curves and shapes best liked by each surgeon. Edges hollow-ground to keen razor sharpness. Especially valuable in bone reconstruction work. Curved gouges ideal for work in and around contoured surfaces.

BOWEN OSTEOTOMES AND CHISELS, hand forged, of 440-C stainless steel, stand up better than instruments of any other material to the hard usage such instruments get. Fine grain structure gives a tough, long-wearing blade. Square grooved handles for sure grip.

BOWEN GOOSENECK Chisels, Osteotomes, and Gouges are designed with the cutting edge offset from the handle. This permits cutting edge to be held at an angle of minimum rake. ALL BOWEN INSTRUMENTS IN STOCK IN ALL STANDARD SIZES.



STAINLESS STEEL INSTRUMENT TRAYS—4 or 6 Unit

- WILL HOLD ANY INSTRUMENT WITH 3/8" SHANK
- TRAYS WILL NEST OR MAY BE PLACED ON END
- INSTRUMENTS STERILIZED WITHOUT HANDLING
- REQUIRE LESS SPACE • CANNOT FALL OUT

Gouge Sizes: 6, 10, 15 & 20 m.m.
Chisels and Osteotomes: 1/4", 1/2", 3/4", 1"

SAFER and QUICKER MENISECTOMIES

Grover Meniscotome

Used through any arthrotomy exposure and on either semilunar cartilage, it guarantees the integrity of all structures within the joint and permits complete removal of either meniscus.

Standard Length 8½"

•

No. 128

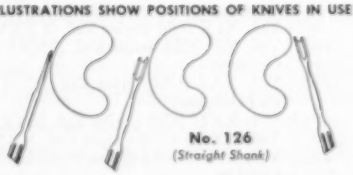
Designed like a large intra-uterine curette, it presents a smooth rounded guard on the outer surface of the ring, the inner margin of which is a keen knife edge permitting cutting in any direction. Its use will shorten by about one-third the present operating time.

Smillie Cartilage Sets

Designed with handles that do not obscure field of vision. Longer beak always rests on tibial table. Beaked knife divides the peripheral attachments of the medial meniscus. Also divides the central attachment of the posterior horn of the lateral meniscus. Second beaked knife used for the same purpose, also to divide the central attachment of the posterior horn of the medial meniscus. Chisel mobilizes middle third of the meniscus.

No. 108
(Curved Shank)

ILLUSTRATIONS SHOW POSITIONS OF KNIVES IN USE



No. 126
(Straight Shank)

• Hand Forged from 440-C Stainless Steel • Keen Cutting Edge • Perfect Balance

BOWEN & COMPANY, INC.

P. O. BOX 5818
BETHESDA, MARYLAND

Wanted

The Editorial Office of *The Journal* is constantly having calls for back issues of *The Journal* and desires to know where copies of the following issues may be obtained when needed:

THE AMERICAN JOURNAL OF ORTHOPEDIC SURGERY

1903–1904: Vol. I, Nos. 1, 2, 3, and 4; August, November 1903; February, May 1904.
1904–1905: Vol. II, Nos. 1, 2, 3, and 4; August, October 1904; January, April 1905.
1905–1906: Vol. III, Nos. 1, 2, 3, and 4; July, October 1905; January, April 1906.
1906–1907: Vol. IV, Nos. 1, 2, 3, and 4; July, October 1906; January, April 1907.
1907–1908: Vol. V, Nos. 1, 2, 3, and 4; July, October 1907; January, April 1908.
1908–1909: Vol. VI, Nos. 1, 2, 3, and 4; August, November 1908; February, May 1909.
1909–1910: Vol. VII, Nos. 1, 2, 3, and 4; August, November 1909; February, May 1910.
1910–1911: Vol. VIII, Nos. 1, 2, 3, and 4; August, November 1910; February, May 1911.
1911–1912: Vol. IX, Nos. 1, 2, 3, and 4; August, November 1911; February, May 1912.
1912–1913: Vol. X, Nos. 1, 2, 3, and 4; August, November 1912; February, May 1913.
1913–1914: Vol. XI, Nos. 1, 2, 3, and 4; July, October 1913; January, April 1914.
1914–1915: Vol. XII, Nos. 1, 2, 3, and 4; July, October 1914; January, April 1915.
1915: Vol. XIII, Nos. 1 and 2; July, October.
1916: Vol. XIV, all twelve issues.
1917: Vol. XV, all twelve issues.
1918: Vol. XVI, all twelve issues.

THE JOURNAL OF ORTHOPAEDIC SURGERY

1919: Vol. I (Old Series Vol. XVII), all twelve issues.
1920: Vol. II (Old Series Vol. XVIII), all twelve issues.
1921: Vol. III (Old Series Vol. XIX), Nos. 1, 2, 3, 4, 6, 9, 10, 11, and 12; January, February, March, April, June, September, October, November, and December.

THE JOURNAL OF BONE AND JOINT SURGERY

1922: Vol. IV (Old Series Vol. XX), Nos. 1, 2, and 3; January, April, and July.
1923: Vol. V (Old Series Vol. XXI), Nos. 1, 2, 3, and 4; January, April, July, and October.
1924: Vol. VI (Old Series Vol. XXII), Nos. 1, 2, 3, and 4; January, April, July, and October.
1925: Vol. VII (Old Series Vol. XXIII), No. 1; January.
1926: Vol. VIII (Old Series Vol. XXIV), Nos. 1, 2, 3, and 4; January, April, July, and October.
1927: Vol. IX (Old Series Vol. XXV), Nos. 1, 2, 3, and 4; January, April, July, and October.
1928: Vol. X (Old Series Vol. XXVI), Nos. 1, 2, 3, and 4; January, April, July, and October.
1929: Vol. XI (Old Series Vol. XXVII), Nos. 1, 2, and 4; January, April, and October.
1930: Vol. XII (Old Series Vol. XXVIII), Nos. 1 and 2; January and April.
1931: Vol. XIII (Old Series Vol. XXIX), No. 1; January.
1932: Vol. XIV (Old Series Vol. XXX), No. 4; October.
1933: Vol. XV (Old Series Vol. XXXI), No. 1; January.
1934: Vol. XVI (Old Series Vol. XXXII), No. 4; October.
1935: Vol. XVII (Old Series Vol. XXXIII), Nos. 1, 2, 3, and 4; January, April, July, and October.
1937: Vol. XIX (Old Series Vol. XXXV), Nos. 1, 3, and 4; January, July, and October.
1938: Vol. XX (Old Series Vol. XXXVI), Nos. 1, 2, 3, and 4; January, April, July, and October.
1939: Vol. XXI (Old Series Vol. XXXVII), Nos. 1, 2, 3, and 4; January, April, July, and October.
1940: Vol. XXII (Old Series Vol. XXXVIII), No. 1; January.
1941: Vol. XXIII (Old Series Vol. XXXIX), No. 1; January.
1944: Vol. XXVI (Old Series Vol. XLII), Nos. 1, 2, 3, and 4; January, April, July, and October.
1945: Vol. XXVII (Old Series Vol. XLIII), No. 2; April.
1947: Vol. 29 (Old Series Vol. XLV), Nos. 1, 2, and 3; January, April, and July.
1948: Vol. 30-A, No. 1; January.

Any reader having copies of the above, which he is willing to dispose of, is requested to correspond with the Editor.

In answering advertisements, please mention *The Journal of Bone and Joint Surgery.*

VOL. 37-A, NO. 2 APRIL 1955

The Journal of
Bone and Joint Surgery

American Volume

ARTICULAR REPLACEMENT FOR THE HUMERAL HEAD

BY CHARLES S. NEER, II, M.D., NEW YORK, N. Y.

From the Department of Orthopaedic Surgery, College of Physicians and Surgeons, Columbia University, and the Fracture Service, Presbyterian-New York Orthopaedic Hospitals, New York

This report presents a method of replacement of the proximal articular surface of the humerus.

In an earlier study the late results of twenty unimpacted fracture-dislocations treated by reduction, excision of the head, or arthrodesis were found unsatisfactory.[6] Reduction was followed by avascular necrosis, because the head was devoid of soft-tissue attachments. Arthrodesis failed because of the associated displacement of the tuberosities. Excision of the head with or without tendon transposition [3] resulted in a flail joint which lacked a fulcrum for abduction and rotation. After excision of the head, the *shoulder* remained uncomfortable and useless for many months until ankylosis through fibrous tissue and bone finally took place. Replacement by a prosthesis presented a logical solution. The initial prosthesis [6] had been designed for the treatment of these injuries.

During recent months seven patients with fracture-dislocations of the shoulder have been treated by replacement of the humeral head and repair of the avulsed tuberosities. In addition, the prosthesis has been used to replace irregular articular surfaces in five patients with old fractures of the humeral neck complicated by avascular necrosis.

DESIGN OF THE PROSTHESIS

The integrity of the flat joint of the shoulder is dependent upon the short muscles, especially in this procedure, since the anterior half of the capsule is divided or excised at the time of replacement. The appliance is designed to replace the articular surface only and the anatomy of the tuberosities and their attachments is disturbed as little as possible.

The articular portion of the prosthesis is formed in the shape of a normal humeral head, with the exception of the superior surface. The superior edge is flattened to permit seating of the prosthesis into the greater tuberosity, so that impingement under the acromion is prevented. The edges are lipped all the way around, so that they can be set into bone. The original prosthesis has been modified to include a three-flange mechanism at the neck which adds fixation and eliminates rotation. A hole is placed in the neck so that the fragments of the tuberosity are held together and to the prosthesis in fresh fracture-dislocations [6] (Fig. 1). The stem diffuses strain over a fifteen-centimeter span. Measurements of seventy-five humeri indicated that the medullary cavities vary in diameter from 0.4 to 2.2 centimeters. An attempt to select one thickness suitable for all cases proved unsatisfactory and the prostheses are now being constructed with three stem sizes (Fig. 1). It is not necessary to have different appliances for the right and left sides; how-

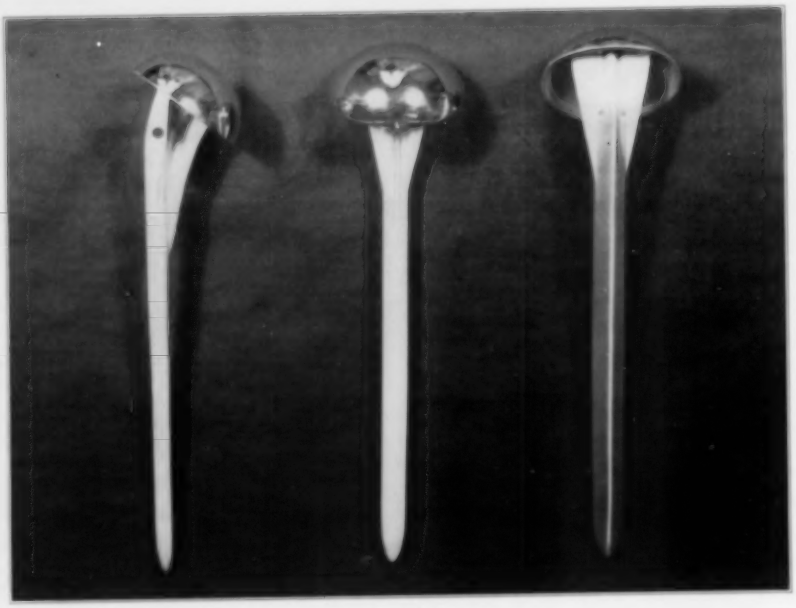


FIG. 1

Photographs of the replacement prosthesis. The small, medium, and large models are shown in side, front, and back views, respectively.

ever, the surgeon must remember that *the normal humeral head faces posteriorly about 20 degrees*. The proper amount of retroversion can be readily selected if the two epicondyles are palpated at the elbow and the head is turned about 20 degrees from their plane.

Vitallium is used for construction of the prosthesis, since it is believed that an inert metal of this type is superior to non-metallic material. The weight has not proved a handicap.

TECHNIQUE

A stem of the proper size should be selected before the operation. The correct size can be determined by taping the appliance to the lateral surface of the arm in the plane it is to occupy and making an anteroposterior roentgenogram. The small, medium, and large prostheses may in turn be measured against the medullary canal in this manner.

The operation is performed with the patient in the "barber-chair" position, the head and knees being raised 30 degrees. The incision is made lateral to the coracoid over the deltopectoral interval, beginning at the clavicle and passing downward 12.5 centimeters. The deltopectoral route is preferred to the transacromial, because the latter results in the problem of a weakened deltoid after operation. The approach should be accomplished with minimum disturbance of muscles and their attachments. The cephalic vein is ligated and removed. The anterior portion of the deltoid is reflected from the clavicle by sharp dissection, enough tissue being left upon the clavicle for reattachment. Thus the deltoid is mobilized laterally sufficiently so that the upper portion of the humerus is seen. The arm is placed in full external rotation, so that the subscapularis tendon is brought into view; this is secured with a stay suture and is then divided from the lesser tuberosity. If a fracture of the lesser tuberosity is present (as in fracture-dislocations) the division of the subscapularis is unnecessary and in such cases the biceps tendon acts as a guide. The capsule is opened transversely. Capsular division and excision must be extensive enough to permit dislocation of the head. In cases of old fracture, the anterior half of the

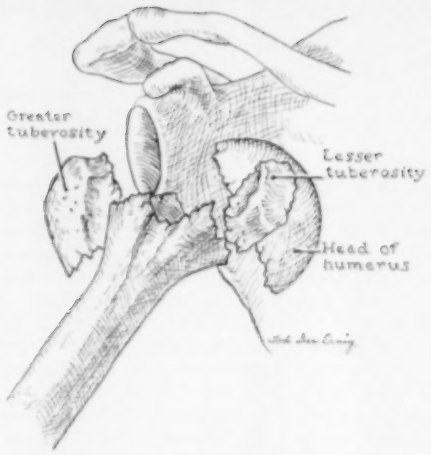


FIG. 2-A

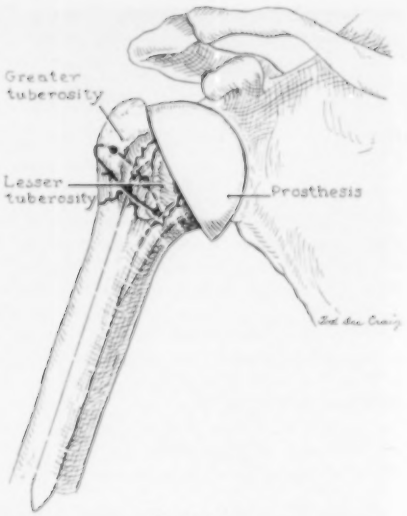


FIG. 2-B

Fig. 2-A: Drawing of a typical fracture-dislocation. The head is detached and lies outside the capsule, the greater tuberosity is pulled backward by the external rotators, and the lesser tuberosity is displaced medially by the subscapularis.

Fig. 2-B: The wire-loop repair, which holds the fragments together, is illustrated.

capsule should be divided. The head is placed into the incision by external rotation and prying with a blunt elevator; this brings the entire articular surface into view. The articulating dome is excised with a broad osteotome. The biceps tendon is detached from the glenoid and is drawn out from its groove. The center of the medullary cavity is found by making a small opening through the cancellous bone in the neck and probing. This opening is enlarged to the size of the stem, so that the neck is prepared to receive the prosthesis and three thin osteotomy cuts are made in the cancellous bone for the three flanges. The prosthesis can then be pushed half-way in by hand, after which the set for the Judet appliance [4] is used to seat the device completely. Before final seating, the rotatory position of the head is checked by palpation of the epicondyles. If the head lacks the normal 20 degrees of retroversion, there may be a tendency toward anterior subluxation. The bone along the neck can be trimmed to proper shape just before the prosthesis is seated.

Recent fracture-dislocations are a special problem. These lesions consistently follow a four-fragment pattern [1,3,6]: (1) the detached head, extracapsular and often rotated as much as 180 degrees; (2) the greater tuberosity, retracted posteriorly by the external rotators; (3) the lesser tuberosity, pulled medially by the subscapularis tendon; and (4) the shaft. A hole is present in the neck of the appliance, so that the tuberosities can be secured to the prosthesis as they are approximated (Fig. 2-B).

Closure should include reattachment of the subscapularis, suture of the biceps, and repair of the detached portion of the deltoid. If the capsule is thickened and shortened, as in all old cases, no attempt is made to repair it. The deltoid and pectoralis fall together and the skin is closed loosely.

After operation the arm is placed in a sling and swathe. Pendulum exercises are begun after forty-eight hours and progressive flexion movements, such as overhead pulley exercising and "wall climbing", are started as soon as the patient can tolerate them. The arm is allowed complete freedom during the daytime from the fourth day. It is bound with a sling and swathe or with a wrist-trunk strap at night for the first three weeks. External rotation and abduction exercises cannot be permitted until the subscapularis has become

reattached, usually at the third week. The importance of this exercise regimen is explained to the patient before operation.

ANALYSIS OF CASES

Twelve replacements of the proximal humeral articulation, according to the method described, were done between January 1953 and April 1954 in the New York Orthopaedic-Columbia-Presbyterian Medical Center.

CASE 1. T. M., a female, aged fifty-four years, had sustained a fracture of the neck of the left humerus thirty-three months prior to admission. This had resulted in avascular necrosis of the humeral head (Fig. 3-A). Pain persisted in spite of months of treatment under the direction of a physical therapist and an orthopaedic surgeon. The patient was strongly left-handed and was unable to hang out clothes or set her hair. Night pain was particularly intense. Examination revealed 10 degrees of painful glenohumeral motion, with a fixed internal-rotation deformity of 20 degrees.

The replacement operation was performed on January 26, 1953. On the day following the operation the patient remarked that "the old pain is now gone". Within ten days after operation she had regained 90 per cent. of shoulder flexion (Fig. 3-C). She resumed her duties as a housewife three weeks after operation and has been free of pain.

Examination twenty-three months after operation indicated a full range of internal rotation, external rotation, and extension. There was loss of flexion of 10 degrees and limitation of abduction of 25 degrees. The site of malunion of the tuberosity had not been disturbed at the time of replacement and this presumably restricted abduction. Strength was excellent and the patient was using the arm for the same activities as before injury. She had no pain and slept well. Roentgenograms indicated good position and absence of resorption.

FIG. 3-A

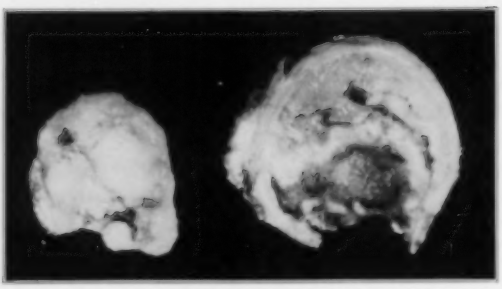


FIG. 3-B

FIG. 3-C

Fig. 3-A: Case 1. The preoperative roentgenogram showed segmental necrosis three years after non-operative treatment of a fracture of the surgical neck of the humerus.

Fig. 3-B: Photograph showing the irregular articular surface and loose body removed at operation.

Fig. 3-C: Photograph showing active elevation eleven days after insertion of the prosthesis. The patient was free from pain.

FIG. 3-D

Roentgenograms made four months after operation, with the arm at the side and overhead.

FIG. 3-E

Photographs made twenty-three months after the replacement procedure.

CASE 2. G. A., a male, aged forty-four years, was admitted three months after he had sustained a posterior dislocation of the shoulder with a fracture of the humeral neck. The fracture-dislocation was unreduced and the arm was fixed in internal rotation of 50 degrees. No definite glenohumeral movement could be elicited. The pain was so intense that the patient could not sleep and was completely incapacitated for his job as a waiter.

The replacement procedure was performed on March 18, 1953. The anterior half of the humeral head was found to be crushed into the tuberosities and the posterior half was rotated extra-articularly and united to the posterior aspect of the glenoid labrum by fibrous tissue and bone (Fig. 4-A). The replacement prosthesis filled the joint space sufficiently so that no tendency to posterior luxation existed after its insertion. Immediate relief of pain was obtained.

FIG. 4-A

FIG. 4-B

Case 2. Illustrating pericapsular ossification following late repair of a neglected fracture-dislocation.

Fig. 4-A: Preoperative roentgenogram showing the posterior fracture-dislocation three months after injury.

Fig. 4-B: Roentgenogram showing ossification posteriorly following replacement. This suggests the need of immediate treatment when extracapsular damage is present.

Three months after operation, the patient returned to regular work in a prominent restaurant, carrying heavy overhead trays. Examination ten months after operation revealed excellent strength. He had no pain. The internal-rotation deformity was no longer present and he had external rotation to the neutral position. Glenohumeral abduction and flexion were limited to 25 degrees. Roentgenograms revealed ossification in the posterior capsule at the site of the initial malunion. It was believed that this was responsible for the limitation of motion. The patient was pleased with his result and did not desire further surgery.

FIG. 5-A

FIG. 5-B

Case 3. Illustrating improper seating of the prosthesis.

Fig. 5-A: Preoperative roentgenogram, showing avascular necrosis one year after open reduction.

Fig. 5-B: The position of the prosthesis, which had not been seated properly, remained unchanged fourteen months after operation. This patient's shoulder was painful after use.

TABLE I

SUMMARY OF CASES

Case No. Initials	Age (*Years*)	Occupation	Preoperative Condition	Duration of Symptoms	Operative Repair	Follow-up (*Months*)	Result Pain	Range of Motion
1. T.M.	54	Housewife	Avascular necrosis	33 mos.	Tuberosities not disturbed	23	None	Good
2. G.A.	44	Waiter	Fracture-dislocation (posterior)	3 mos.	Tuberosities not disturbed	10	None	Poor
3. L.G.	39	Housewife	Avascular necrosis	15 mos.	Tuberosities not disturbed	14	With use	Good
4. J.S.	52	Housewife	Avascular necrosis	1 yr.	Tuberosities not disturbed	20	None	Excellent
5. A.L.	67	Mail clerk	Fracture-dislocation (anterior)	12 hrs.	Wire-loop repair	18	None	Good
6. G.H.	66	Housewife	Fracture-dislocation (anterior)	3½ mos.	Wire-loop repair and stapling	6	None	Poor
7. A.O.	44	Nurse	"Impression fracture" Fracture-dislocation (posterior)	3 wks.	Tuberosities not disturbed	12	None	Good
8. T.M.	65	Building superintendent	Fracture-dislocation (anterior)	1 mo.	Stapling. Tuberosities not disturbed.	3	"Satisfactory"	
9. F.A.	61	Physician	Fracture-dislocation (posterior)	1 mo.	Tuberosities not disturbed	3	"Satisfactory"	
10. B.D.	54	Painter	Fracture-dislocation (anterior)	24 hrs.	Wire-loop repair	8	None	Fair
11. I.S.	70	Housewife	Hypertrophic osteo-arthritis	3 yrs.	Tuberosities not disturbed	7	None	?
12. G.L.	46	Housewife	Fracture-dislocation (posterior)	8 days	Wire-loop repair	2	None	?

CASE 3. L.G., a female, aged thirty-nine years, was admitted one year after a fracture-dislocation of the left shoulder. An open reduction had been performed in another hospital and avascular necrosis and collapse of the humeral head had apparently resulted. Pain and crepitation were pronounced.

A replacement operation was performed on April 17, 1953, and the relief of pain was striking. Roentgenograms made after operation revealed incomplete seating of the prosthesis. However, the patient required no analgesia after the initial twenty-four-hour period. She was discharged from the Hospital on the fifth day after operation.

At examination fourteen months after operation the patient was working as a housewife. The range of motion in the shoulder was as follows: flexion to 155 degrees, abduction to 135 degrees, extension to 35 degrees, and full internal and external rotation as compared with the normal side. The patient was pleased with the range of movement, but stated that she had considerable discomfort in the shoulder after use.

Roentgenograms indicated no change in the position of the prosthesis (Fig. 5-B). It occupied the same cephalad position as before operation. There was no resorption.

Case 4. J. S., a female, aged fifty-two years, was admitted twelve months following an unimpacted fracture of the humeral neck of the left shoulder. Roentgenograms indicated that the articular surface of the head was lying free within the joint as a loose body (Fig. 6-A). To complicate the problem, this patient had undergone partial scapulectomy six years previously; this had resulted in a 60 per cent. reduction of scapulo-

Fig. 6-A

Fig. 6-B

Fig. 6-A: Case 4. Preoperative roentgenograms showing the original fracture.

Fig. 6-B: Roentgenogram made twelve months later, showing segmental necrosis of the head.

Fig. 6-C

Roentgenograms, made with the arm at the side and with the arm actively abducted, showing the range of motion twelve months after the replacement procedure.

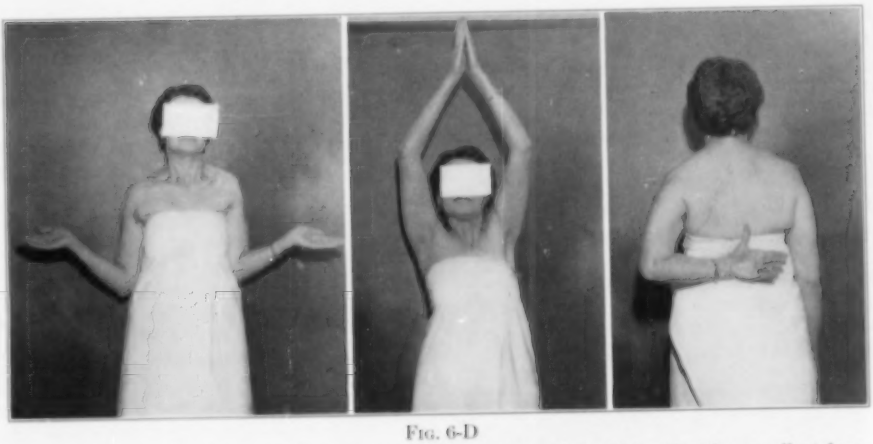


FIG. 6-D

Photographs made twenty months after the replacement procedure. The patient has excellent function, in spite of an old partial scapulectomy.

thoracic motion. There was severe restriction of glenohumeral movement and it was impossible for her to reach her mouth, chest, or buttocks. Pain was marked.

Articular replacement was performed on April 30, 1953. Full passive glenohumeral motion was present at the conclusion of the procedure. The patient was able to reach her mouth and button her clothing for the first time in months. Roentgenographic studies made after operation revealed the prosthesis to be subluxated inferiorly, but roentgenograms made twelve days later indicated normal position. The patient returned to her regular duties as a housewife after two weeks. She sustained an ankle fracture four months later and for a period of twelve weeks used crutches without difficulty.

At examination twenty months after operation there was full range of glenohumeral motion (Fig. 6-D). Strength was excellent. The patient had no pain. She used her arm for all housework without difficulties. Roentgenographic studies revealed no absorption about the prosthesis.

CASE 5. A. L., a male, aged sixty-seven years, sustained a comminuted, unimpacted fracture of the left humeral neck on June 18, 1953. The fracture was exposed twelve hours after injury and the head fragment was found to be devoid of soft-part attachments. The replacement procedure was performed and the two tuberosities were reduced and fixed together and to the prosthesis. The patient was discharged from the Hospital twelve days later with detailed instructions in exercises. He returned to regular work as a clerk two and a half months after operation, at which time roentgenographic studies revealed bony union between the tuberosities and the shaft.

At examination eighteen months following operation, he had good strength and no pain except for an occasional mild weather ache. He could flex to 145 degrees, abduct to 150 degrees, and extend to 20 degrees; external rotation was to 15 degrees, and internal rotation was the same as in the normal side. Roentgenographic studies indicated firm seating of the prosthesis. He was working at his regular job as a mail clerk.

CASE 6. G. H., a housewife, aged sixty-six years, sustained a fracture-dislocation of the right shoulder in July 1953. She was admitted to the New York Orthopaedic-Columbia-Presbyterian Medical Center in November 1953, at which time it was discovered that the humeral head was still lying outside the capsule and was rotated 60 degrees. The anterior rim of the glenoid fossa had been fractured coincidentally. There was no detectable shoulder motion. Operation on November 17, 1953, consisted of replacement of the humeral head and stapling of the capsule to the anterior aspect of the glenoid rim. The patient required no medication for pain after the fifth day.

At examination six months after operation the patient had no pain and was performing her duties as a housewife. Extensive repair tissue had been encountered at the time of replacement; this probably accounted for the fact that glenohumeral motion was limited to about 20 per cent. of normal at the time of this examination. Roentgenograms indicated good position of the prosthesis.

CASE 7. A. O., a female, aged forty-four years, entered the Hospital in November 1953, having sustained a posterior fracture-dislocation of the right shoulder while receiving electroshock therapy two weeks previously. The arm was fixed in full internal rotation. Closed reduction attempted under general anaesthesia had failed.

On December 3, 1953, it was noted after open reduction that a severe "impression" fracture was present,

the anterior 60 per cent. of the articular surface of the humerus having been crushed into the tuberosities (Fig. 7-A). This defect in the head caused the shoulder to dislocate when the arm was brought to neutral rotation. A small-stem prosthesis was inserted and this filled the joint sufficiently to restore stability. The arm was placed in balanced suspension for the first seven days after operation. A temporary subluxation was then noted (Fig. 7-B). The patient returned to her regular duties as a nurse six weeks later.

At examination twelve months after operation there was no pain. Excessive lifting of patients caused shoulder fatigue; however, she was nursing without handicap. The range of motion in the shoulder was: flexion to 160 degrees, abduction to 160 degrees, extension to 30 degrees, and full internal and external rotation as compared with the normal side (Fig. 7-C). Roentgenographic studies indicated absence of reaction and good position. The patient was pleased with the result.

Case 8. T. M., a female, aged sixty-five years, presented an untreated anterior fracture-dislocation of the shoulder of one month's duration. Closed reduction was attempted and failed. On January 28, 1954, an open reduction was performed, at which time it was discovered that the articular cartilage was lifted from the head, exposing three quarters of the underlying cancellous bone. The lesser tuberosity of the humerus and the anterior rim of the glenoid fossa were fractured and displaced into a mass of repair tissue. A prosthesis was used to replace the head and the anterior capsule was fixed to the glenoid rim with a staple. Pendulum exercises were begun one week later, at which time the patient had almost no pain. She was discharged from the Hospital three weeks after operation.

Fig. 7-A

This patient refused to return for outpatient treatment because she did not have time. A report from her family physician three months after operation indicated that the patient was doing her regular work as a building superintendent and that she had no complaints. He was unable to describe the range of motion but thought it was satisfactory.

Case 9. F. A., a male, aged sixty-one years, presented a badly disorganized posterior fracture-dislocation of the right shoulder of five weeks' duration. The intra-articular portion of the humerus was broken into many pieces, the largest of which was extruded posteriorly, and fractures of both tuberosities had healed with

Fig. 7-B

Fig. 7-C

Fig. 7-A: Case 7. This patient sustained an "impression fracture", with posterior luxation of the head and distortion of more than half of the articular surface. These lesions are usually produced by electroshock therapy, as was the case in this patient.

Fig. 7-B: Roentgenogram made seven days after operation, showing temporary subluxation.

Fig. 7-C: Roentgenogram made twelve days later, showing restoration of the normal position as muscle tone had been regained.

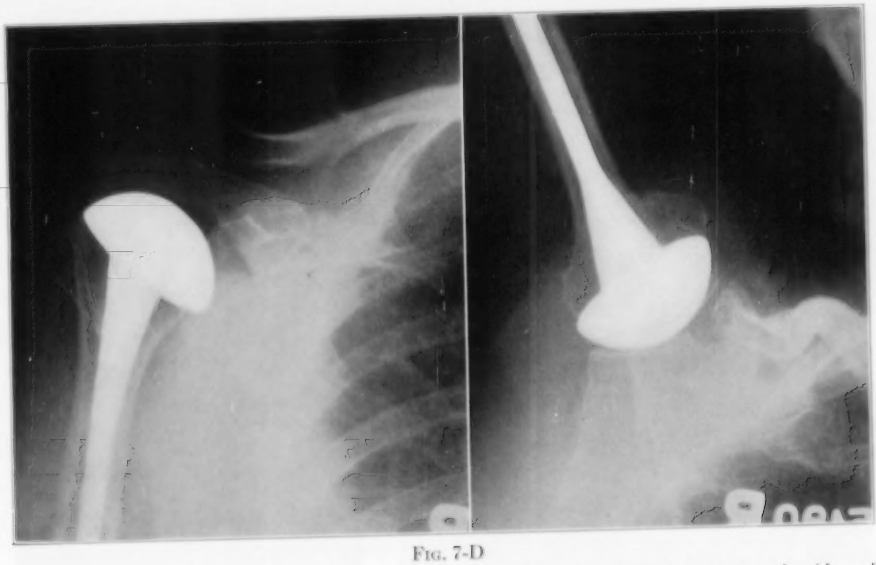


FIG. 7-D

Roentgenograms made twelve months after the replacement procedure, with the arm at the side and overhead.

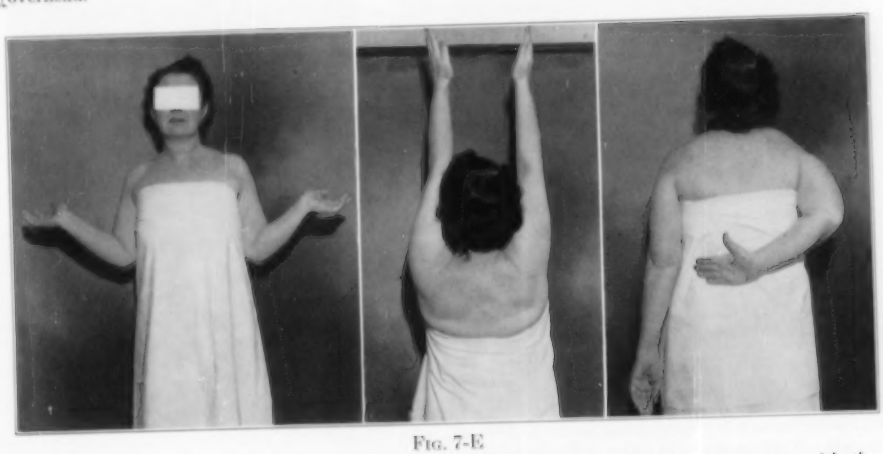


FIG. 7-E

Photographs, made twelve months after the replacement operation, showing the patient with the arms in external rotation, internal rotation, and abduction. The strength in both arms was good.

displacement. On February 16, 1954, the joint was exposed from the front and, after removal of the head fragments, the prosthesis was inserted.

This patient, a physician, returned to his home in South America one month after operation and has not been seen since. He referred a patient, Case 12, to this Hospital two months later with a similar injury, who reported that the physician was doing well.

CASE 10. B. D., a male, fifty-four years old, sustained a typical four-fragment anterior fracture-dislocation of the right shoulder on February 24, 1954 (Fig. 8-A). The reconstruction operation was performed twenty-four hours after injury. The head was lying outside the joint and was detached from the soft parts, except for a thin strand of ligament. The greater and lesser tuberosities were displaced by the external rotators and subscapularis tendons. The head was removed and was replaced with the large-stem prosthesis. The tuberosities were approximated as shown in Figure 2-B. Roentgenograms made after operation indicated a tendency for the prosthesis to subluxate inferiorly, but, as exercises were continued and muscles regained tone, this tendency disappeared. The patient returned to his work as an artist five weeks after operation, at

FIG. 8-A

FIG. 8-B

Fig. 8-A: Case 10. Preoperative roentgenogram of a typical anterior fracture-dislocation, showing the head detached and lying outside the capsule.

Fig. 8-B: Roentgenogram made two months after wire-loop repair, showing the tuberosities uniting to the shaft.

In more recent cases a finer wire has been used and it has been carefully buried in the tendons.

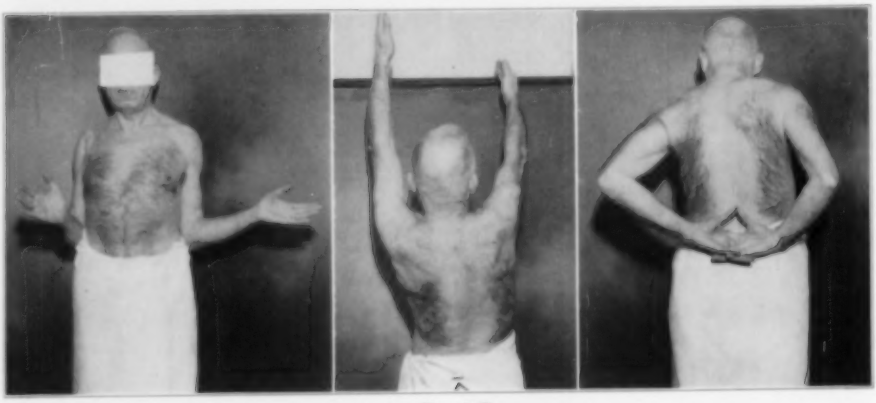


FIG. 8-C

Photographs, made ten months after wire-loop repair, showed only fair recovery of motion. However, the patient was free from pain.

which time he had no pain. Roentgenographic studies made six weeks after operation showed bridging callus between the tuberosities and the shaft.

The patient returned two months after operation complaining of pain and fever. Examination revealed an area of fluctuation under the operative scar. He was readmitted and a superficial abscess was drained. Cultures revealed hemolytic *Staphylococcus aureus* sensitive to all antibiotics. Treatment with terramycin was begun. Three weeks later the wound had closed and the patient resumed his work and his program of exercise. The infection was superficial to the prosthesis and it was not necessary to remove the appliance. The patient had resumed work and was free of pain ten months later (Fig. 8-C).

CASE 11. I. S., a female, aged seventy years, entered the Hospital after one year of unsuccessful non-operative treatment for a painful, stiff left shoulder. Roentgenograms revealed the marginal osteophytes and thinning of the joint space characteristic of osteo-arthritis. There had been an injury three years previously, which suggested a traumatic basis for the degeneration. Glenohumeral motion was restricted to about 20 degrees and the movement was accompanied by marked crepitus and pain.

On March 16, 1954, the joint was explored; a humeral head with irregular contours and almost devoid of

FIG. 9-A

FIG. 9-B

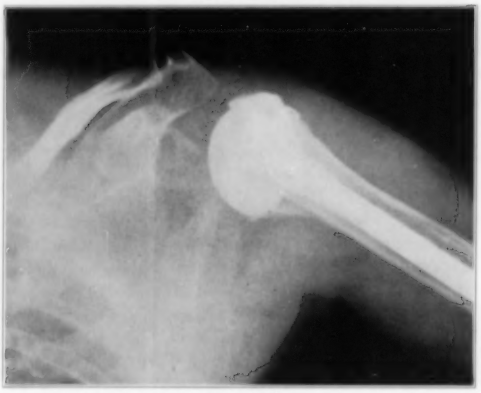


FIG. 9-C

Figs. 9-A and 9-B: Case 12. Preoperative anteroposterior and axillary roentgenograms of a posterior fracture-dislocation. The head was rotated 90 degrees.

Fig. 9-C: Postoperative roentgenogram illustrating the repair.

articular cartilage was revealed. Under anaesthesia it was impossible to move the glenohumeral joint to more than 20 degrees of abduction. The articulating dome was removed and, after insertion of the prosthesis, it was possible to move the shoulder through a full range of motion. Thirty-six hours after operation the patient remarked that she had less pain than before the operation. She returned to her home in the Middle West ten days after operation.

She has not been examined since that date. However, she informed us by letter seven months later that she was free of pain and "leading a new life".

CASE 12. G. L., a female, aged forty-six years, was admitted to the Hospital with a comminuted posterior fracture-dislocation of eight days' duration. On April 23, 1954, a replacement operation was performed and the disrupted tuberosities were reduced and fixed to the prosthesis (Fig. 9-C). After operation the arm was placed in balanced suspension for fourteen days. Initially there was a temporary tendency for the prosthesis to subluxate inferiorly. The patient was free from pain when she was discharged from the Hospital twenty-eight days after operation.

At examination eight weeks after surgery the patient could abduct to 120 degrees and flex to 160 degrees. She had no pain. She returned to her home in South America at that time.

Each of these patients had been suffering from either a recent extra-articular extrusion and detachment of the humeral head or a long-standing painful incongruity of the humeral articulation. In the latter situation conservative treatment had been tried and had failed in every instance. The replacement procedure was followed by a remarkably pain-free convalescence. The stiffness present in Case 2 and Case 6 (Table I) suggests the need of early reconstruction of extra-articular lesions before extensive repair occurs. A tendency toward inferior subluxation of the prosthesis was observed after operation in four patients, but this disappeared as soon as muscle tone had been regained. There were no other complications, with the exception of the superficial wound infection in Case 10. There

have been no dislocations. Eleven of the twelve patients are free from pain, the one instance of improper seating of the prosthesis, Case 3, being the exception. None of these patients require further operative treatment.

DISCUSSION

The literature contains many references to the soft-part structures of the shoulder joint, but little attention has been given to the articulating surface. Glenohumeral motion is dependent upon the fulcrum action of the humeral head and, contrary to previous belief [2,3,5], excision of the humeral head does not result in acceptable function [6]. So far, results of the operation described have been found to be superior to those of head resection. An arthrodesis of this joint requires a long time to consolidate and is particularly difficult and uncertain if it is performed upon necrotic bone or a fresh fracture. Properly performed, articular replacement is followed by a relatively short and asymptomatic convalescence. Although there has been insufficient time for adequate follow-up, it is logical to assume that a prosthesis would wear better in this non-weight-bearing joint than in the hip.

REFERENCES

1. Codman, E. A.: The Shoulder. Rupture of the Supraspinatus Tendon and Other Lesions in or about the Subacromial Bursa. Ed. 1, p. 319. Boston, Privately printed, 1934.
2. DePalma, A. F.: Surgery of the Shoulder. Ed. 1, p. 271. Philadelphia, J. B. Lippincott, 1950.
3. Jones, Laurence: The Shoulder Joint. Observations on the Anatomy and Physiology with an Analysis of a Reconstructive Operation Following Extensive Injury. Surg., Gynec., and Obstet, **75:** 433–444, 1942.
4. MacAusland, W. R.: Replacement of the Femoral Head by a Prosthesis for the Reconstruction of the Hip Joint. A Report on the Judet Method. Surg., Gynec., and Obstet., **92:** 513–528, 1951.
5. McLaughlin, H. L.: The Treatment of Injuries to the Shoulder. *In* Regional Orthopaedic Surgery and Fundamental Orthopaedic Problems, Instructional Courses of The American Academy of Orthopaedic Surgeons, 1946, p. 103. Ann Arbor, J. W. Edwards, 1947.
6. Neer, C. S.; Brown, T. H., Jr.; and McLaughlin, H. L.: Fracture of the Neck of the Humerus with Dislocation of the Head Fragment. Am. J. Surg., **85:** 252–258, 1953.

EARLY WEIGHT-BEARING AND THE CORRECTION OF ANTEVERSION IN THE TREATMENT OF CONGENITAL DISLOCATION OF THE HIP *

BY E. GEORGE CHUINARD, M.D., PORTLAND, OREGON

From the Shriners' Hospital for Crippled Children, Portland

The purpose of this paper is to present the method and the results of treatment of congenital dislocation of the hip at the Shriners' Hospital for Crippled Children in Portland, Oregon. The routine of treatment has been developed gradually since 1942 and, at the present time, includes a simple x-ray technique for the detection of anteversion, the use of skeletal traction prior to reduction, the use of immobilization in a position of inward rotation and abduction for the maintenance of reduction, the use of a walking peg to permit weight-bearing in the cast, and, finally, the correction of anteversion by subtrochanteric osteotomy. This routine is applicable mainly to children from eighteen months to eight years of age. It is well recognized that younger children respond satisfactorily to varied types of abduction treatment and that, as the age progresses, it becomes increasingly necessary to do either an open reduction or a high shelf operation. These latter procedures have been necessary less often as our experience with this routine has increased.

MATERIAL

Since 1942, 100 patients with 129 congenital dislocations of the hip have been treated. Anteversion was diagnosed in sixty-nine (53 per cent.) of 129 hips, and forty-three hips (62 per cent.) of the sixty-nine with anteversion were treated by subtrochanteric osteotomy. In addition to the 100 patients treated since 1942, 118 patients, eighteen months to eight years of age who had been treated from 1923 to 1942, were also studied for the sole purpose of comparing the number of open reductions. Only congenital dislocations, unassociated with other conditions, have been included.

ROUTINE OF TREATMENT

Roentgenographic Examination

Whenever a dislocated hip is suspected, a "scouting" roentgenogram is made. This is an anteroposterior view of the pelvis with the full length of both femora in the neutral position (Fig. 5-A). It is important to have the pelvis flat and the lower extremities aligned, with the feet pointing directly forward. A second roentgenogram is then made with the lower extremities abducted, inwardly rotated, and with traction applied, care being exercised to keep the pelvis flat (Fig. 5-B). Comparison of these roentgenograms will indicate the presence and degree of anteversion and often will give some idea of the reducibility of the hip. If only dislocation is suspected, "push-pull" roentgenograms are also made. Oblique roentgenograms of the pelvis will help to determine if the femoral head is anterior or posterior to the acetabulum (Fig. 2). The roentgenograms made after reduction also include the pelvis and the full length of the femora.

Skeletal Traction

Unless the clinical and roentgenographic examination indicates that the dislocation can be reduced without anaesthesia or with almost no effort under anaesthesia, traction is applied by means of a small Steinmann pin placed transversely through the lower end of the femur. Serial roentgenograms are made and the weight of traction is increased until

* Read at the Annual Meeting of The American Academy of Orthopaedic Surgeons, Chicago, Illinois, January 28, 1954.

FIG. 1

FIG. 2

Fig. 1: Anteroposterior roentgenogram, with the full length of the femora, shows bilateral dislocation without anteversion.

Fig. 2: An oblique view of the pelvis will indicate more easily and more clearly than stereoscopic views whether the head is anterior or posterior to the acetabulum. In this roentgenogram, the left femoral head is seen at the level of the acetabulum, but posterior to it. The roentgenogram was made by placing the patient in the position used for making a lateral roentgenogram of the lumbosacral area and by rolling him forward 30 degrees from this position.

the femoral head is pulled down to or even slightly below the acetabulum. If anteversion is present and the head has not rotated inwardly toward the socket, upward traction is applied to the outer end of the pin to produce inward rotation (Figs. 3-A, 3-B, and 3-C).

Reduction

Reduction is often possible without anaesthesia, with or without a sedative. A plaster spica is applied to maintain the reduction. Occasionally the frog-leg position is used when the head is not seated in the acetabulum in the position of inward rotation and abduction; the position of such hips is changed to abduction and inward rotation within a few weeks. If reduction cannot be effected *without force*, traction is resumed. Repeated unsuccessful attempts at reduction, particularly in the older children, is considered an indication for open reduction.

The Walking Peg

When the roentgenograms made after reduction show the head of the femur to be seated in the acetabulum, a weight-bearing peg is applied to the cast at the knee (Figs. 4-A and 4-B). The peg is a crutch tip with metal extensions which encircle the cast and are secured with plaster bandages. Weight-bearing is encouraged as soon as the cast is dry. Any child old enough to walk promptly learns to do so with facility in the cast, even learning to pirouette on the peg; patients affected bilaterally need more assistance, but some learn to walk alone. After a few days of active walking, a roentgenogram is made to check on the reduction. The child is then encouraged to walk as much as possible.

Thereafter the cast is changed and roentgenograms are made as indicated. If anteversion is present, the patient is allowed about six months of walking in the cast. He is then either given a trial of walking without support or an osteotomy is done. If an osteotomy is considered to be necessary, it is done before the hip is mobilized so that the secure seating of the femoral head in the acetabulum will not be disturbed.

Subtrochanteric Osteotomy

The subtrochanteric area of the femur is readily accessible for osteotomy. The incision is made with the lower extremity maintained in the position of inward rotation. The anterior surface of the neck, the head of the femur, and the rim of the acetabulum are palpated to check the reduction and the effect of outward rotation of the femur. A Steinmann pin is inserted into the neck of the femur in a horizontal plane. A second pin is placed in the shaft about one inch below the lesser trochanter in an anteroposterior direction. It is so placed that when the anteversion is corrected by osteotomy it will be rotated outward to the first pin. For example, with 90 degrees of anteversion, the second pin is inserted perpendicular to the first. In practice, this second pin usually will be parallel to the traction pin in the lower end of the femur. The osteotomy is performed between the pins by means of an osteotome, and the distal fragment is rotated outwardly until the pins come together. In this series of cases, various methods have been used to control the fragments; these include a Lane plate and screws, a Blount plate, staples, wire loops, and a single Steinmann pin in the neck. However, only the two-pin method has given consistently satisfactory control of the fragments (Fig. 5-D). The wound is closed with the pins crossing at the skin line. They are then incorporated in the plaster cast. At the end of six weeks, the pins are removed through a window in the cast, and about two weeks later the cast is removed. There have been no complications from the use of pins and no infections.

RESULTS

Table I shows that the incidence of congenital dislocation of the hip was greater in females than in males in a ratio of slightly over three to one and that the left hip was involved in patients affected unilaterally in a ratio of slightly over two to one.

Patients with bilateral dislocation were seen for treatment on an average of six months to one year later than those with unilateral dislocation, the latter averaging slightly over two years of age when seen.

Inasmuch as the main purpose of this study was to determine the possible effects of anteversion and its correction by subtrochanteric osteotomy, the patients were divided into four groups, unilateral dislocations with and without osteotomy, and bilateral dislocations with and without osteotomy.

Because none of the patients have reached adulthood, final results cannot be evaluated. The results to date have been rated simply as *good* or *poor*, *good* denoting results in patients in whom there is no clinical impairment and in whom reduction has been maintained and *poor* designating results in patients in whom there is some impairment and some redislocation.

There were twenty-six patients with unilateral dislocation in whom subtrochanteric osteotomy was done (Group I); in four of these the results were not ratable because of the recent date of the osteotomy, while in the remaining twenty-two the results in eighteen (82 per cent.) were rated *good*. In contrast, the results in 77 per cent. of thirty-nine patients with unilateral dislocation in whom no osteotomy had been done (Group III) were rated *good*. There were ten patients with bilateral dislocation in whom seventeen subtrochanteric osteotomies had been done (Group II). In one osteotomy the result could not be rated; of the remaining sixteen osteotomies, the results in seven (43 per cent.) were rated *good*. In contrast, the results in 37 per cent. of nineteen patients with bilateral dislocation in whom osteotomy had not been done (Group IV) were rated *good* (Table I).

TABLE I

	No. of Cases	Average Age Treatment Was Begun (*No. of Cases*)	(*Age*)	Sex		Hip		Acetabular Index		Age at Osteotomy		Results			
				Male	Female	Right	Left	Normal (*Average*)	Dislocated (*Average*)	(*No. of Cases*)	(*Age*)	Good (*No. of Cases*)	Good (*Per cent.*)	Poor (*No. of Cases*)	Poor (*Per cent.*)
Group I *	26	21	26 mos.	8	18	10	16	20	34	19	32 mos.	18	82.	4	18.
										7	5 yrs. plus		(4 cases not ratable)		
		2	5 yrs.												
		2	6 yrs.												
		1	7 yrs.												
Group II	10 **	9	35 mos.	3	7			34 (R)	36 (L)	9	48 mos.	7	43.	9	57.
										1	7 yrs.		(1 hip not ratable ***)		
Group III	45	40	27 mos.	7	38	12	33	36	19			30	77.	9	23.
													(6 cases not ratable ***)		
Group IV	19	15	33 mos.	5	14			39 (R)	38 (L)			7	37.	12	63.
		2	5 yrs.												
		2	6 yrs.												

* Group I: patients with unilateral dislocation in whom subtrochanteric osteotomy was done; Group II: patients with bilateral dislocation in whom subtrochanteric osteotomy was done; Group III: patients with unilateral dislocation in whom no osteotomy was done; and Group IV: patients with bilateral dislocation in whom no osteotomy was done.

** Seventeen subtrochanteric osteotomies.

*** Not ratable because treatment has not yet been completed; the child is still in cast.

TABLE II

Relation of Anteversion to End Results

	Results	Unilateral No. of Cases	Unilateral Average Age (*Months*)	Unilateral Per cent.	Bilateral No. of Cases	Bilateral Average Age (*Months*)	Bilateral Per cent.
Anteversion treated by subtrochanteric osteotomy	Good	18	31.1	82.	7	35.4	44.
	Poor	4	28.5	18.	9	38.4	56.
Anteversion not treated by subtrochanteric osteotomy *	Good	3	29.0	36.	3	38.0	25.
	Poor	7	28.4	64.	9	41.3	75.

* In these groups, of course, the patients had less anteversion: 30 to 60 degrees.

TABLE III

RELATION OF ANTEVERSION TO OPEN REDUCTION

	Open Reduction	
	Unilateral (*Per cent.*)	Bilateral (*Per cent.*)
Anteversion treated by subtrochanteric osteotomy	15. 4 of 26	35. 7 of 20
Anteversion not treated by subtrochanteric osteotomy	18. 2 of 11	50. 6 of 12

In the patients with unilateral dislocation, good results were obtained in 82 per cent. of those with recognized anteversion who had been treated by osteotomy; in patients with recognized anteversion who had not been treated by osteotomy, good results were obtained in 36 per cent. In patients with bilateral dislocation and recognized anteversion who had been treated by osteotomy, good results were obtained in 43 per cent., while in those with recognized anteversion who had not been treated by osteotomy good results were obtained in 25 per cent. (Table II). These figures become more significant in view of the

TABLE IV

COMPARISON OF NUMBER OF OPEN REDUCTIONS IN ALL CASES
(Children Eighteen Months to Eight Years Old)

	Unilateral		Bilateral	
	Closed	Open	Closed	Open
Before 1942	75 hips		86 hips	
118 patients; 161 hips	62 (88 per cent.)	13 (17 per cent.)	69 (80 per cent.)	17 (20 per cent.)
After 1942	71 hips		58 hips	
100 patients; 129 hips	63 (89 per cent.)	8 (11 per cent.)	39 (68 per cent.)	19 (32 per cent.)

fact that the patients with recognized anteversion who had not been treated by osteotomy had a lesser degree of anteversion (30 to 60 degrees) than those patients who had been treated by osteotomy. Table II shows that there was no significant influence of age on the results.

In patients with unilateral dislocation who had been treated by subtrochanteric osteotomy, open reduction was required in 15 per cent., while in those not treated by osteotomy, open reduction was required in 18 per cent. The comparable figures for patients with bilateral dislocation are 35 and 50 per cent., respectively (Table III).

In Table IV the incidence of open reductions before 1942 is compared with that after

TABLE V

RELATION OF ACETABULAR INDEX TO GOOD AND POOR RESULTS
(Figure Is Average Index of Dislocated Hips)

	Good (*Degrees*)	Poor (*Degrees*)
Group I	38	35
Group II	32	38
Group III	36	37
Group IV	37	40

FIG. 3-A FIG. 3-B FIG. 3-C

Fig. 3-A: Roentgenogram shows dislocation of the left hip and external rotation of the femur without anteversion.

Fig. 3-B: Skeletal traction pulled the head down opposite the acetabulum; the femur remained rotated.

Fig. 3-C: The effect of inward-rotation traction applied to the outer end of the Steinmann pin is shown. The head is seen to be directed toward the acetabulum and there is no anteversion.

TABLE VI

RESULTS IN OLDER PATIENTS (FIVE YEARS OF AGE OR MORE)

	Good	Poor
Group I	4	2
Group II	1	0
Group III	2	3
Group IV	0	4
Total	7	9

1942 when the present routine of treatment was begun. In patients with unilateral dislocation, open reduction was done in 17 per cent. before and in 11 per cent. after 1942; in patients with bilateral dislocation, open reduction was done in 20 per cent. before and in 32 per cent. after 1942. In this group of patients nineteen open reductions were done after 1942; in these only seven osteotomies were done. Only one open reduction has been done since September 1947. In the group of patients who had been treated by osteotomy, skeletal traction was used in three. Of the patients who were not treated by osteotomy, only two were treated by traction. In retrospect, it is thought that greater use of traction would have given better results.

The acetabular index [15] was essentially the same in all patients and showed no relationship to good and poor results. It is, therefore, probably of no prognostic importance (Table V).

In sixteen patients five or more years of age, the results were good in seven (44 per cent.) and were poor in nine (66 per cent.). In the group with good results, five patients had been treated by osteotomy, while only two patients in the group with poor results had been treated by osteotomy (Table VI).

In Group I three of the patients in whom a good result was obtained after osteotomy had, at one time, been considered for an open reduction. Of the six patients in this group five or more years of age with good results, two had been considered for open

FIG. 4-A

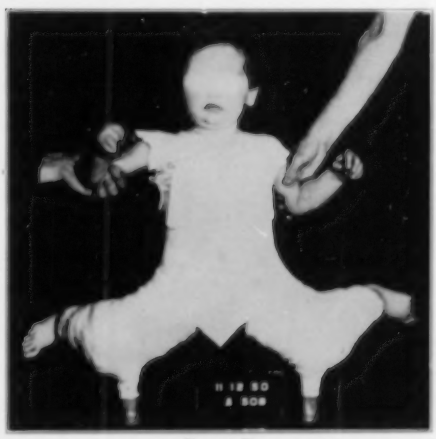


FIG. 4-B

Fig. 4-A: The hip had been reduced in a position of abduction and inward rotation. The walking peg was attached to the cast.

Fig. 4-B: Although some patients with bilateral dislocation learn to ambulate alone in the cast, most of them need help.

FIG. 5-A

FIG. 5-B

FIG. 5-C

Fig. 5-A: Dislocation of the hip with acetabular index of 45 degrees. There is slight anteversion seen on comparison with the other hip. The dislocated head is small.

Fig. 5-B: Abduction and inward rotation produced full antero-posterior view of the neck and a more lateral view of the knee.

Fig. 5-C: Roentgenogram made after reduction and after the walking cast had been used for seven months. There were no epiphyseal changes. The femoral heads cannot be easily rotated from the acetabulum. Note the difference in the aspects of the knees of the two extremities.

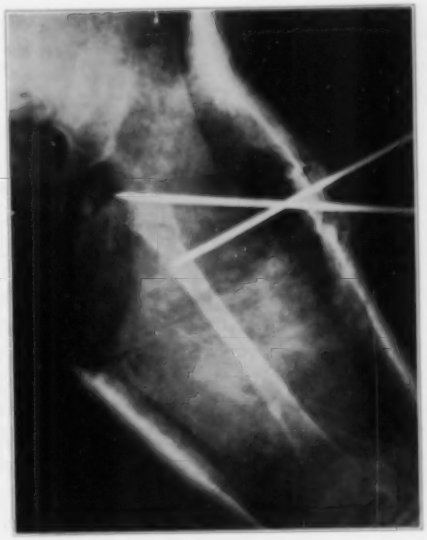


FIG. 5-D

Fig. 5-D: Roentgenogram made after subtrochanteric osteotomy. Note the anteroposterior view of the femoral neck and the knee.

FIG. 5-E

Fig. 5-E: Roentgenogram made five months after subtrochanteric osteotomy. The acetabular index is 30 degrees. The femoral head has developed to nearly normal size. There is full motion, the hip is stable, and there are no symptoms.

reduction. One patient in this group with a poor result had been subjected to six closed and two open reductions. Although the results are rated clinically *good* at present, four hips are slightly dislocated and are being watched closely. The acetabular index in these four hips was 24, 22, 30, and 45, respectively. Dislocation, therefore, is not necessarily related to a high acetabular index.

In Group II, there were two patients with good results bilaterally and three patients with good results on one side only. The most significant finding in this group was that better function was found in those hips in which open reduction had not been done.

In Group III, three hips showed slight dislocation by roentgenograms, but the results at present are clinically good. The four patients in whom open reduction had been done and the two in whom shelf stabilization had been done had anteversion. Of the three patients with slight dislocation and the eight with poor results, seven (63 per cent.) had anteversion. Of the five patients in this group five or more years of age, there were two with good results and three with poor results.

In Group IV, the patient with the highest acetabular indexes (right, 59; left, 43) had aseptic necrosis bilaterally. In one patient the Lorenz bifurcation osteotomy had been done bilaterally; in both hips the result was poor. In this patient anteversion was present bilaterally and the acetabular index was high (45 and 46). The seven patients with good results bilaterally had on the average an acetabular index of 40 on the right and 37 on the left as compared with the group average which was 39 on the right and 38 on the left. There were thirteen cases of aseptic necrosis; the results in six hips were good and the results in seven were poor. The results were poor in nine (75 per cent.) of the twelve hips with anteversion. In the four patients in this group five or more years of age, the results were poor.

FIG. 6-A

Congenital dislocation of the hip in a five-year-old child who had had no previous treatment. Acetabular index was 38 degrees. Anteversion was suspected.

DISCUSSION

Anteversion

Although anteversion has been consistently recognized by most authors as one of the factors in dysplasia of the hip joint, there has been no consistency of opinion regarding its importance. Opinions vary from those who consider it of little or no importance [5,11,12] to those who consider it a major factor [1,7,16]. It is the author's contention that anteversion is of equal importance with the other components of the dysplasia. The x-ray technique herein described will indicate quite reliably the presence of anteversion, and will show the degree of the deformity with sufficient accuracy to permit clinical evaluation of its importance. A roentgenogram showing only the upper end of the femur may suggest anteversion, but unless the whole femur is studied as a unit (Figs. 3-A, 3-B, and 3-C) no conclusions can be drawn.

All too frequently anteversion is regarded as coxa valga, or no attention is paid to the deformity which is merely suggested by inadequate roentgenograms. Physical examination may indicate its presence, but proper roentgenographic examination is essential. Various methods have been devised to ascertain the degree of anteversion [8,9,14,30,33], but as yet it is not common practice to determine clinically the amount of anteversion prior to closed or open reduction. Muller and Seddon refer to the unpublished work of Seddon and Trevor, who "have found that even in the early case of congenital dislocation the various methods of estimating anteversion are surprisingly unreliable when checked by the accurate measurements made at operation".

It must be kept in mind that a normal degree of anteversion * in congenital dislocation of the hip may contribute to the insecurity of the reduction and that surgical alteration of anteversion which is at the upper limit of normal may bring the sum of dysplastic factors within the range of correctability by what Gill terms the "normal growth processes". What degree of anteversion is pathological from the standpoint of preventing reduction or contributing to redislocation must be decided in each case. Observation and trial rather than precision determination of the exact degree of anteversion in each case must decide this point. This and other studies [4] have shown that there is no correlation between the acetabular index and good and poor results, and that age and anteversion do affect the results. Inasmuch as we do not yet know to what extent normal growth processes can correct anteversion after reduction, we believe that anteversion should be corrected surgically, if it is of possible troublesome degree, particularly since in all probability the "growth processes", instead of being normal, are also involved in the dysplasia.

* Le Damany believed the average anteversion at birth to be from +30 to +50 degrees, which rapidly decreased during the first two years of life. Kingsley and Olmstead found an average of 24.4 degrees in thirty infant femora with a range of −10 to +64. Dunlap and his associates found a normal of +31 degrees in the early months of life, which rapidly declined to +23.7 at the end of the second year.

FIG. 6-B

After treatment with traction, the dislocation was reduced and the extremity was immobilized in the position of abduction and inward rotation. The patient was immobilized in a walking cast for five and a half months. No epiphyseal changes are apparent. Anteversion was proved by the antero-posterior view of the femoral neck and the lateral view of the knee. Subtrochanteric osteotomy was done on October 28, 1946.

FIG. 6-C

Roentgenogram made six years after osteotomy. Acetabular index was 21. The hip was normal clinically.

TABLE VII

RELATIONSHIP OF USE OF WALKING PEG TO THE INCIDENCE OF ASEPTIC NECROSIS *

	Patients Using Walking Peg (*No.*)	(*Months*)	Aseptic Necrosis (*No. of Hips*)	(*Per cent.*)	Time Aseptic Necrosis Appeared	Good Results in Hips with Aseptic Necrosis (*Per cent.*)
Group I	20	7	5	25.	5 cases after subtrochanteric osteotomy.	50.
Group II	6 (12 hips)	4½	5	42.	1 bilateral case with walking peg. Unilateral cases after subtrochanteric osteotomy.	0
Group III	33	6	8	24.	8 cases after weight-bearing in walking peg completed.	75.
Group IV	19 (38 hips)	4¾	13	34.	1 bilateral case with walking peg. Other cases after weight-bearing with walking peg completed.	46.
Incidence of aseptic necrosis in all patients				30.**		

* Summary: There were 103 hips. Weight-bearing continued from two to twelve months. In four hips (two patients), changes occurred while the patient was bearing weight in the walking cast. In twenty-five hips, changes developed after the beginning of ambulation, following the use of the walking peg, whether or not the patient had been treated by osteotomy.

** There were five children in whom epiphyseal changes in the hip were present prior to treatment. These children were treated according to the routine described with the exception that weight-bearing was not permitted. If these five patients are included in the computation, the incidence of aseptic necrosis in this series was 33.3 per cent. (thirty-six of 108 patients).

Fairbank believes that, if the dislocation is reduced before the fourth year, the need for an osteotomy is rare. Langenskiold states that, when anteversion is as great as 60 degrees, it must be corrected. Platou [26] accepts 30 degrees of anteversion as being abnormal and indicating need of an osteotomy. Muller and Seddon, Durham, and Massie and Howorth place the figure at 45 degrees. We believe that the younger the patient, the more likely it is that correction of the anteversion will occur. We are inclined to accept 45 degrees in the younger and 30 degrees in the older (two or more years) patients as the indication for osteotomy.

Skeletal Traction

Crego has emphasized the importance of skeletal traction in the treatment of congenital dislocation of the hip. In our opinion any patient with a dislocated hip which is not virtually reduced, as shown by roentgenograms made with the extremity in abduction and inward rotation with manual traction (Fig. 5-B), should be treated by skeletal traction. It is the only method which provides absolute skeletal control, both for axial traction and inward rotation. This is particularly necessary in the high and long established dislocations. A slight amount of overpull is advantageous and makes the reduction easy and atraumatic and perhaps serves to bring the head below the limbus.

If skeletal traction is used and if the Steinmann pin has been placed transversely in the lower end of the femur, the inward inclination of the pin that occurs as the femur pulls down is a dependable indicator of the degree of anteversion, providing the progress roentgenograms show that a reduction or near reduction has been obtained.

There have been no complications with the use of skeletal traction.

Position of Reduction

There are two positions in common use for maintaining reduction,—the frog-leg position and the position of inward rotation and abduction. Krida reduces the dislocation in the frog-leg position, and then, in about two weeks, changes this to a position of inward rotation and abduction. Platou [26] brings the hip more gradually from the frog-leg position toward a neutral position.

We have used the position of inward rotation primarily in all patients except three in whom the frog-leg position seemed to give a more stable reduction; in these the position was changed to inward rotation and abduction in two to three weeks. The use of the position of inward rotation primarily seems important since it is conjecturally possible that the sudden change from the frog-leg position to that of inward rotation, amounting to a rotation of approximately 180 degrees (as practised by Krida), might strangle the blood supply in the capsule, thereby contributing to epiphyseal changes. It has been pointed out repeatedly that closed reduction must be maintained long enough to permit adaptive changes in the soft tissues. Inasmuch as the position of inward rotation is the one of functional reduction, the more promptly this position is obtained, the sooner desired adaptive changes in the ligaments, capsule, and muscles occur. Furthermore, the position of inward rotation is necessary in order to permit the use of the weight-bearing peg,—an essential part of our routine.

The Walking Cast

The importance of function of the hip while reduction in abduction is maintained has been emphasized repeatedly and methods of accomplishing it have been explored by many investigators [2,29]. However, these methods have disregarded the presence and effect of anteversion; for weight-bearing has been accomplished by removing the cast below the knee. This permits free rotation, and redislocation of the anteverted head may occur.

Blount, in 1931, called attention to the peg-leg cast as used by Roeren; this appears not to have come into wide use.

It seems reasonable to believe that, if reduction alone can displace intervening soft tissue in the acetabulum, as reported by Severin on the basis of his extensive arthrographic studies, weight-bearing should be more effective in seating the head deeply in the socket by displacement or attrition of the soft tissues. Bauer emphasized the importance of weight-bearing in molding the primary acetabulum by citing the effect of the dislocated head in producing a secondary socket.

No injurious effects have developed from use of the walking cast. Stiffness after removal of the cast has been minimal, lasting only a few days, in contrast to the prolonged limitation of motion following open reduction. One supracondylar infraction (0.8 per cent.) occurred in this series after the cast had been removed. Platou [27] reported fifty infractions in 406 hips (12 per cent.) probably due to the atrophy resulting from several months' bed rest in the cast.

The Subtrochanteric Osteotomy

Preferably the osteotomy should be done in the subtrochanteric portion of the femur. Watkins, in 1915, advocated the subtrochanteric site and credited Prof. Schede as being the first advocate of osteotomy at this level. The supracondylar region is perhaps more accessible but it is definitely removed from the abnormal anteversion, and derotation at this level may not be successful. The subtrochanteric site has the following advantages: (1) It permits finger exploration of the position of the head in relation to the acetabulum, and (2) it moves the insertion of the glutaeus maximus posteriorly to its normal position. When the anteverted hip is reduced by inward rotation the insertion of the glutaeus maximus is rotated from its normal posterolateral position to an anterolateral one. If the

insertion of this muscle is left unaltered, as it is with a supracondylar or mid-shaft osteotomy, the pull of the muscle may be a factor in causing redislocation since it would tend to produce external rotation and anterior dislocation of the head. It seems possible that some of the redislocations occurring after these lower osteotomies may be due to the uncorrected rotatory effect of the glutaeus maximus. Perhaps the iliopsoas transplantation to counteract outward rotation as practised by Laurent would not be required if his osteotomies were done at the subtrochanteric level instead of at the mid-shaft level.

The patient is kept in the walking cast for at least six months before the osteotomy is performed. If the anteversion is slight and the patient is young, a trial of free ambulation may be warranted in order to see if the natural growth processes will accommodate for the deformity and maintain the reduction. However, we have come to feel that, if there is any doubt, osteotomy should be performed. This opinion is supported by the data given in Table II; poorer results were obtained in the hips in which it was considered that growth might compensate for slight anteversion, and osteotomy was not done.

Somerville believes the anteversion should be corrected following open reduction, and before ambulation is permitted. This study suggests that all indicated extra-articular procedures should be done before resorting to open reduction. Crego has pointed out that anterior transposition will occur as frequently after open reduction as after closed reduction, if anteversion is present.

The method described here provides skeletal control of the degree of desired correction, until the osteotomy heals, and leaves no foreign material in a growing child.

There have been no complications, except that in one case a second osteotomy was necessary to correct excessive valgus, and in another one inch of shortening resulted when an attempt was made to effect better alignment of the fragments by rimming the cast. In this patient roentgenograms showed too much abduction of the distal fragment, which, if permitted to heal in this position, would give too great a degree of coxa valga. Thus the cast was rimmed around at the site of osteotomy and the distal fragment was brought into more adduction.

Aseptic Necrosis

No effort has been made to study epiphyseal changes except in relation to the use of the weight-bearing peg. It was thought that weight-bearing might produce damage to the head instead of stimulating development of the hip joint.

Table VII summarizes the incidence and time of appearance of aseptic necrosis in this series. The incidence is 33.3 per cent. Weight-bearing on 103 hips was begun immediately after reduction and was continued for two to twelve months. Five patients had changes in the head prior to reduction which continued to progress during treatment; these were not permitted to bear weight. In four hips (two bilateral cases) changes developed while the patients were in the walking cast, and twenty-five hips first showed changes after unsupported ambulation was begun. These findings suggest that it is not weight-bearing alone which is the cause of these changes, but rather weight-bearing when the congruous relationship of the head to the socket has been relinquished by discontinuation of treatment in the cast.

Massie drew attention to the wide variation in the incidence of aseptic necrosis as reported by various authors, ranging from none (Crego and Schwartzmann) to 52 per cent. (Bost and his associates). The incidence of 33.3 per cent. in the present series is between that of Leveuf (23 per cent.) and that of Ponseti (46.2 per cent.).

It seems justifiable to conclude that the use of the weight-bearing cast has not increased the incidence of aseptic necrosis.

The comparison of good results in Table VII with good results in Table I shows a lower percentage of good results in patients with aseptic necrosis in each group than

for the group as a whole, except in Group III. This bears out the general observation that aseptic necrosis unfavorably affects the results in congenital dislocation of the hip.

CONCLUSIONS

1. From this study it appears that we have not used skeletal traction and derotation osteotomies frequently enough, although their use has become more frequent as this routine of treatment has been developed.

2. There is no correlation between the acetabular index and good and poor results.

3. Uncorrected abnormal anteversion does affect the results adversely.

4. Correction of anteversion by osteotomy decreases the necessity for open reduction.

5. Anteversion should be corrected before a turndown shelf operation or intra-articular procedures are done.

6. No specific degree of anteversion can be accepted as a definite indication for derotation osteotomy in all ages. The younger the child, the more likely it is that the "natural growth processes" will correct the anteversion. Any doubt should be resolved in favor of doing the osteotomy. In the author's opinion 30 degrees of anteversion is an indication for doing a derotation osteotomy.

7. It is the author's belief that the subtrochanteric area is the proper site for the derotation osteotomy.

8. The walking cast used after reduction does not appear to increase the incidence of aseptic necrosis of the femoral head.

REFERENCES

1. Badgley, C. E.: Correlation of Clinical and Anatomical Facts Leading to a Conception of the Etiology of Congenital Hip Dysplasias. J. Bone and Joint Surg., **25**: 503–523, July 1943.
2. Bauer, Felix: Functional Treatment of Congenital Dislocation of the Hip-joint. Proc. Roy. Soc. Med., **34**: 215–217, 1941.
3. Blount, W. P.: The Peg-Leg Cast. J. Bone and Joint Surg., **13**: 107–121, Jan. 1931.
4. Bost, F. C.; Hagey, Helen; Schottstaedt, E. R.; and Larsen, L. J.: The Results of Treatment of Congenital Dislocation of the Hip in Infancy. J. Bone and Joint Surg., **30-A**: 454–468, Apr. 1948.
5. Bradford, E. H.: The Treatment of Congenital Dislocation of the Hip. J. Bone and Joint Surg., **5**: 76–98, 1923.
6. Crego, C. H., Jr.: Preliminary Skeletal Traction in the Treatment of Congenital Dislocation of the Hip. Southern Med. J., **26**: 845–851, 1933.
7. Crego, C. H., Jr., and Schwartzmann, J. R.: Follow-up Study of the Early Treatment of Congenital Dislocation of the Hip. J. Bone and Joint Surg., **30-A**: 428–442, Apr. 1948.
8. Dunlap, Knox; Shands, A. R., Jr.; Hollister, L. C., Jr.; Gaul, J. S.; and Streit, H. A.: A New Method for Determination of Torsion of the Femur. J. Bone and Joint Surg., **35-A**: 289–311, Apr. 1953.
9. Dunn, D. M.: Anteversion of the Neck of the Femur. A Method of Management. J. Bone and Joint Surg., **34-B**: 181–186, May 1952.
10. Durham, H. A.: Anteversion of the Femoral Neck in the Normal Femur and Its Relation to Congenital Dislocation of the Hip. J. Am. Med. Assn., **65**: 223–224, 1915.
11. Fairbank, H. A. T.: Congenital Dislocation of the Hip: With Special Reference to the Anatomy. British J. Surg., **17**: 380–416, 1930.
12. Gill, A. B.: End Results of Early Treatment of Congenital Dislocation of the Hip. J. Bone and Joint Surg., **30-A**: 442–453, Apr. 1948.
13. Howorth, M. B.: Congenital Dislocation of the Hip. Technic of Open Reduction. Ann. Surg., **135**: 508–519, 1952.
14. Kingsley, P. C., and Olmstead, K. L.: A Study to Determine the Angle of Anteversion of the Neck of the Femur. J. Bone and Joint Surg., **30-A**: 745–751, July 1948.
15. Kleinberg, Samuel, and Lieberman, H. S.: Acetabular Index in Infants in Relation to Congenital Dislocation of the Hip. Arch. Surg., **32**: 1049–1054, 1936.
16. Krida, Arthur: Congenital Dislocation of the Hip; the Effect of Anterior Torsion; a Procedure for Its Correction. J. Bone and Joint Surg., **10**: 594–604, July 1928.
17. Krida, Arthur: Congenital Dislocation of the Hip Joint. Am. J. Surg., **6**: 185–193, 1929.
18. Krida, Arthur: Congenital Dislocation of the Hip. General Consideration and System of Curative Treatment. Surg. Clin. North America, **22**: 553–563, 1942.

19. Langenskiold, F.: Technical Aspects of the Operative Reduction of Congenital Dislocation of the Hip. Acta Orthop. Scandinavica, **20**: 8–11, 1950.
20. Laurent, L. E.: Congenital Dislocation of the Hip. Acta Chir. Scandinavica, Supplementum 179, 1953.
21. Le Damany, P.: Congenital Luxation of the Hip. Am. J. Orthop. Surg., **11**: 541–567, Apr. 1914.
22. Leveuf, J.: Primary Congenital Subluxation of the Hip. J. Bone and Joint Surg., **29**: 149–162, Jan. 1947.
23. Massie, W. K.: Vascular Epiphyseal Changes in Congenital Dislocation of the Hip. Results in Adults Compared with Results in Coxa Plana and in Congenital Dislocation without Vascular Changes. J. Bone and Joint Surg., **33-A**: 284–306, Apr. 1951.
24. Massie, W. K., and Howorth, M. B.: Congenital Dislocation of the Hip. Part II. Results of Open Reduction as Seen in Early Adult Period. J. Bone and Joint Surg., **33-A**: 171–198, Jan. 1951.
25. Muller, G. M., and Seddon, H. J.: Late Results of Treatment of Congenital Dislocation of the Hip. J. Bone and Joint Surg., **35-B**: 342–362, Aug. 1953.
26. Platou, Eivind: Rotation Osteotomy in the Treatment of Congenital Dislocation of the Hip. J. Bone and Joint Surg., **35-A**: 48–54, Jan. 1953.
27. Platou, Eivind: Luxatio Coxae Congenita. J. Bone and Joint Surg., **35-A**: 843–866, Oct. 1953.
28. Ponseti, Ignacio: Causes of Failure in the Treatment of Congenital Dislocation of the Hip. J. Bone and Joint Surg., **26**: 775–792, Oct. 1944.
29. Ridlon, John: Congenital Dislocation of the Hip. Surg. Clin. Chicago, **1**: 271–286, 1917.
30. Ryder, C. T., and Crane, Lawrence: Measuring Femoral Anteversion: The Problem and a Method. J. Bone and Joint Surg., **35-A**: 321–328, Apr. 1953.
31. Severin, Erik: Congenital Dislocation of the Hip. Development of the Joint after Closed Reduction. J. Bone and Joint Surg., **32-A**: 507–518, July 1950.
32. Somerville, E. W.: Open Reduction in Congenital Dislocation of the Hip. J. Bone and Joint Surg., **35-B**: 363–371, Aug. 1953.
33. Stewart, S. F., and Karshner, R. G.: Congenital Dislocation of the Hip. A Method of Determining the Degree of Antetorsion of the Femoral Neck. Am. J. Roentgenol., **15**: 258–260, 1926.
34. Watkins, J. T.: Congenital Dislocation of the Hip. Reduced by Manipulation Followed by Arthrotomy. J. Am. Med. Assn., **65**: 1803–1804, 1915.

DISCUSSION

Dr. A. R. Shands, Jr., Wilmington, Delaware: Dr. Chuinard has given a good analysis of the treatment of patients with congenital dislocation of the hip who have been seen at the Shriners' Hospital in Portland, Oregon, over the last thirty years. He has presented a method of treatment which is rather novel,—one which is definitely new to me but which appears quite sound. His good results certainly bear testimony to the value of this procedure. His statements concerning the part which anteversion plays in the end results are very true.

Since 1951, our Clinic has been much interested in a method to determine accurately the amount of anteversion by roentgenograms. The method for the determination of anteversion which Dr. Chuinard has reported—namely, the comparison of two sets of roentgenograms, one with the foot and lower extremity pointed forward and the other with the lower extremity in abduction and internal rotation and with traction —is a modification of the two-roentgenogram method which was first reported in the American literature in 1926 by Farrell, von Lackum, and Smith, and was referred to by Krida, in 1928, as Drehmann's method. It is my opinion that the fluoroscopic methods reported by Stewart and Karschner, in 1926, and by Rogers, in 1931, should be more accurate than Dr. Chuinard's method or the Drehmann method.

The idea of not performing a derotation osteotomy until the patient has been allowed to walk in the special cast for six months is good. During this period of weight-bearing, the head of the femur certainly should become well positioned and well fixed in the acetabulum. The end results should be better with this delayed osteotomy than with osteotomy being performed immediately after or in a few weeks following the reduction. Concerning the type of subtrochanteric osteotomy he has described, we have been using essentially the same technique for eight years for the correction of coxa vara and have had excellent results; we certainly prefer it to other methods.

The author's statistics on open reductions and osteotomies for excessive anteversion are not convincing, for I do not believe accurate conclusions can be drawn from a series of so few cases. However, the conclusions reached after a comparison of the results in those patients in whom a derotation osteotomy was done with those in patients in whom no osteotomy was done are quite convincing. With his arbitrary figures of when to perform an osteotomy—namely, 45 degrees of anteversion for those under two years of age, and 30 degrees for those over two years of age—I feel most orthopaedic surgeons who believe in the necessity for derotation osteotomies will agree. If such figures are to be used as guides, a more accurate method should be employed than the author's method for determining anteversion. With our method (the Dunlap method) which we consider as accurate as any now in use, the readings in patients with excessive anteversion can vary as much as 20 degrees, usually because of faulty positioning or positioning which does not take into consideration

the anterior bowing of the femur. For an accurate determination, the lateral roentgenogram of the hip must be made with the hip and knee at 90 degrees of flexion and with the hip in 10 degrees of abduction. For a determination of true torsion, a posterior-anterior roentgenogram of the hips and pelvis must be made, the shaft-neck angle must be measured, and this angle should be used with the measured torsion to obtain the true torsion by means of the special charts for the correction of error.[a]

Since our anteversion technique has been employed, roentgenograms of 1,180 hips in 590 children have been made. Of this number, there have been thirty-six patients with congenital dislocation of the hip. However, in the first nineteen patients, the roentgenograms were made in abduction of 35 degrees, which we know now resulted in a high percentage of inaccurate readings. In seventeen of these patients with twenty-one congenitally dislocated hips, roentgenograms have been made with the minimum abduction of 10 degrees, which we feel is the correct amount. Eight of the twenty-one hips in patients from two to three years of age showed an average anteversion of + 52 degrees, varying from 37 to 65 degrees; eight hips in patients from four to six years of age showed an average anteversion of + 46 degrees, varying from + 35 to + 74 degrees, and five hips in patients from seven to fourteen years of age showed an average anteversion of + 44 degrees, varying from + 28 degrees to + 62 degrees.

Some of our other findings are of interest. They are as follows: In coxa plana, two of thirteen hips had an excessive anteversion of + 41 degrees and + 51 degrees, respectively; however, in one of these thirteen hips, there was a decrease in anteversion to + 3 degrees. In three cases of congenital coxa vara, there was a decrease in anteversion; one of these was a child of eight years with + 7 degrees on the right and − 1 degree on the left. In two patients of four and three years of age, with rachitic coxa vara, the anteversion was − 4 and − 3 degrees, and − 8 and − 20 degrees, respectively. In four patients with congenitally short limbs, there was a decreased anteversion, one having a reading of − 10 degrees. All of these patients with congenitally short limbs had coxa valga, which in dislocated hips is usually associated with an increased anteversion.

In conclusion, I wish to compliment Dr. Chuinard on his splendid presentation and know that it will be another publication to stimulate interest in anteversion or what Galeazzi has said is the most important single factor in the development, treatment, and prognosis of congenital dislocation of the hip.

a. Dunlap, Knox; Shands, A. R., Jr.; Hollister, L. C., Jr.; Gaul, J. S., Jr.; and Streit, H. A.: A New Method for Determination of Torsion of the Femur. J. Bone and Joint Surg., **35-A:** 289–311, Apr. 1953.

b. Farrell, B. P.; von Lackum, H. L.; and Smith, A. DeF.: Congenital Dislocation of the Hip. A Report of Three Hundred and Ten Cases Treated at the New York Orthopaedic Dispensary and Hospital. J. Bone and Joint Surg., **24:** 551–561, July 1926.

c. Krida, Arthur: Congenital Dislocation of the Hip; the Effect of Anterior Dislocation; a Procedure for Its Correction. J. Bone and Joint Surg., **10:** 594–604, July 1928.

d. Rogers, S. P.: A Method for Determining the Angle of Torsion of the Neck of the Femur. J. Bone and Joint Surg., **13:** 821–825, Oct. 1931.

e. Stewart, S. F., and Karschner, R. G.: Congenital Dislocation of the Hip. A Method of Determining the Degree of Antetorsion of the Femoral Neck. Am. J. Roentgenol., **15:** 258–260, 1926.

Dr. Chuinard (closing): I wish to thank Dr. Shands for his critical review of my paper and for his suggestions and kind remarks. He has properly pointed out the limitations of the x-ray technique which we have used. I think Dr. Shands and I are in agreement on two important points,—that the recognition and evaluation of anteversion is necessary and that the full length of the femur must be studied roentgenographically in order to make such an evaluation.

The comparison of x-rays which include the full length of the femora in various positions will indicate excessive anteversion. The main point is not how much anteversion there is, but whether there is too much anteversion to permit the maintenance of reduction. The determination of the exact degree of anteversion does not tell us whether a patient will need a derotation osteotomy. Any orthopaedic surgeon who believes in the importance of anteversion will undoubtedly correct anteversion of 60 to 90 degrees.

The review of our own cases has shown that the results are poorer in patients with lesser degrees of anteversion—that is, 30 to 60 degrees—in whom an osteotomy was not done. In these we expected that the natural growth processes would be able to carry on with the proper development of the hip joint, once reduction had been obtained. A derotation osteotomy in such patients serves to decrease by one the factors of the dysplasia which contribute to the instability of the hip. A period of observation with the patient out of the walking cast in these "in-between" cases is probably more important in determining the need for osteotomy than is the determination of the exact degree of anteversion. Even though the exact and complete correction of the anteversion may not have been accomplished, the osteotomy will probably bring the deformity within the range of correctability by the natural growth processes.

I do not mean to imply that the attempt to determine the exact degree of anteversion is only of academic importance. Such an attitude would preclude further investigation. Inasmuch as the exact determination of the degree of dysplasia in the soft tissues is not possible, we should make every attempt to measure those factors which easily lead to an exact determination.

(Continued on page 298)

FURTHER EXPERIENCE WITH EXTRA-ARTICULAR ARTHRODESIS OF THE SUBTALAR JOINT *

BY DAVID S. GRICE, M.D., BOSTON, MASSACHUSETTS

From the Massachusetts Infantile Paralysis Clinics, Children's Hospital, Boston

A preliminary report was presented to The American Orthopaedic Association in 1950 of an extra-articular arthrodesis of the subtalar joint for the correction of paralytic flat feet. Because of the limited experience with this method, the paper was not submitted for publication until December 1951, at which time the results in twenty-two patients were reported [1]. Since this is a relatively new procedure and one in which the indications and limitations must be defined before it is accepted, it seemed appropriate to present subsequent experiences with this operation. This report will discuss the results of the procedure in fifty-two patients, with paralytic feet resulting from poliomyelitis, who were subjected to operation prior to one year ago. The incidence and prevention of the operative complications will be stressed. The author appreciates that further follow-up studies of these patients are indicated before the procedure can be finally evaluated, but

TABLE I

AGE OF PATIENTS AT OPERATION AND DURATION OF FOLLOW-UP

	Age at Operation							
Years	4	5	6	7	8	9	10	Over 10
No. of patients	2	8	9	1	10	5	4	13
	Duration of Follow-up							
Years	1	2	3	4	5	9		
No. of patients	15	14	12	7	3	1		

considerable experience has been obtained relative to the operative technique and to some of the indications for the types of tendon transplantation which have been useful with this procedure.

The longest follow-up in this series is that of a fourteen-year-old boy who has been followed for nine years after operation. Twenty-three of the patients have been followed for at least three years since operation, and fourteen have been followed for only two years. Fifteen patients were operated upon less than two years ago, but these have had at least a one-year follow-up. The two youngest patients in this series were four years old at the time of surgery. Seventeen patients were between the ages of five and six. Thirty of the patients in this series were eight years old or younger when the operation was performed. The oldest patient in this series was thirty-eight years old. The question has been raised as to the youngest age at which this procedure can be done; there seems to be little indication for its use before the age of four years in poliomyelitic patients. The deformity can be controlled moderately well for the first few years, and sufficient deformity to warrant this operation rarely develops before the age of four. Only six patients were operated upon as early as two years after the onset of poliomyelitis, the majority of the patients being operated upon between four and seven years after the onset of poliomyelitis (Table I).

In addition to those patients who have had the procedure carried out for poliomyelitic deformities, extra-articular subtalar fusion, with bone grafts, has also been performed on

* Read at the Annual Meeting of The American Orthopaedic Association, Bretton Woods, New Hampshire, June 8, 1954.

sixteen other feet in an attempt to correct severely pronated feet, talipes valgus associated with cerebral palsy and spina bifida, talipes valgus associated with plantar flexion of the talus, and a post-traumatic foot following a compound fracture of the tibia with loss of the tibialis posterior. The results in this group of patients will not be discussed in this paper.

In the original paper, it was proposed that this operation could be done as a definitive procedure in very young children during the period of active growth, rather than deferring surgery until the child is old enough to have a triple arthrodesis performed. It was indicated that this procedure would correct the deformity, would restore the height of the foot, and would not interfere with subsequent growth. These have proved to be the major objectives in advocating this procedure. However, as more experience has been gained with the method, it has also been used in the older group of patients, in preference to triple arthrodesis for the correction of valgus deformities. In the older patients in whom the extra-articular arthrodesis was performed, the procedure was usually done a few years after the onset of poliomyelitis when it was still possible to restore the normal architecture of the foot and to maintain the correction by the insertion of grafts in the sinus tarsi. In selecting patients for this procedure, it is essential that it be determined before operation that the calcaneus can be restored to its normal position beneath the talus. This can usually be confirmed by manipulating the foot into a position of equinus and inversion and by making a lateral roentgenogram. If a severe valgus deformity has been present for many years, such structural changes will have occurred that the calcaneus cannot be displaced beneath the head of the talus without resection of the articular surfaces.

The oldest patient in this series was thirty-eight years old at the time of the extra-articular subtalar fusion, but it was only four years after the onset of poliomyelitis. The deformity in this instance was not too severe preoperatively. Her peroneal muscles were rated *fair* and were barely strong enough to provide good dorsiflexion when they were transplanted. Both peroneals had to be moved forward to the second and third metatarsals. The fusion of the subtalar joint was, therefore, carried out to provide lateral stability in the absence of the peroneal muscles. The valgus deformity of the foot was corrected, and a good weight-bearing foot resulted.

EVALUATION OF RESULTS

All of the fifty-two cases have been reviewed during the past three months, and an attempt has been made to establish some criteria for classifying the end results. Since the purpose of this study is to evaluate the possible causes of failure in this procedure, it was decided not to classify the results in the usual manner (excellent, good, fair, and poor). The results have been classified either as *good* (the foot demonstrates good function and a satisfactory cosmetic appearance) or as a *complication*, in which case an attempt has been made to evaluate the cause of the difficulty. Of the total group of fifty-two patients, good results were obtained in forty-one patients. None of the patients had pain in the ankle or in the mid-tarsal joints when they were seen at follow-up examination. Such difficulties as were seen were those related to inadequate correction of the valgus deformity or to overcorrection of the valgus deformity with resultant poor weight-bearing. There were seven patients with inadequate correction and four with overcorrection of the deformity after the initial procedure.

Loss of Correction

In two patients correction was not maintained because the grafts had been improperly placed in the sinus tarsi, and complete loss of correction had occurred before the patients were allowed to bear weight. In both of these patients the situation could have been remedied immediately after the operation if the wound had been opened and the grafts had been correctly replaced in the sinus tarsi. Instead of this, a closed manipulation

FIG. 1-A

Fig. 1-A: Case A. Z., February 6, 1953, at the age of six and one-half years, three and a half years after the onset of poliomyelitis.

FIG. 1-B

Fig. 1-B: Photographs made on March 5, 1954, one year after the operation. A good weight-bearing foot resulted.

was done under anaesthesia; in both instances, it was unsuccessful. Subsequently, these patients were subjected to re-exploration, and it was observed that the grafts had united to the talus but had not united to the calcaneus. The grafts were removed, the foot was realigned, and new grafts were inserted in the sinus tarsi. In both instances, following the second operation, a satisfactory fusion took place and a good result was obtained. The problem is illustrated by the following case history:

A. Z., female, had acute poliomyelitis in 1949 at the age of three years. She had residual paralysis of the left tibialis anterior and tibialis posterior. The other muscles of the foot and leg were rated *good* or were normal. In February 1953, at the age of six and a half years, she was admitted to the Hospital for correction of a severe valgus deformity (Figs. 1-A and 1-C). An extra-articular arthrodesis of the subtalar joint was performed, but tendon transplantation was deferred because of persistent equinus deformity. Roentgenograms made after the operation showed inadequate correction of the deformity and showed the grafts in poor position (Fig. 1-D). The foot was manipulated under anaesthesia, but the position of the grafts was not improved. Three months later, in May 1953, roentgenograms showed that there had been a further loss of correction (Figs. 1-E and 1-G). The patient was admitted to the Hospital for tendon transplantation. In June 1953, the peronaeus brevis was transplanted to the talonavicular area, and the subtalar arthrodesis was revised. The old grafts were removed from the sinus tarsi. The calcaneus was replaced beneath the talus, and autogenous grafts were obtained from the previous donor site in the tibia. Exercises were done out of the cast six weeks later, and weight-bearing was allowed twelve weeks after the operation. The final result is shown in Figures 1-B, 1-F, and 1-H.

Numerous modifications have been proposed for accomplishing the fusion of the subtalar joint by the extra-articular technique. We have continued to use the two bone grafts placed in the sinus tarsi because they provide greater stability than would a single graft and are easier to align correctly than are two grafts placed in slots in the bones. It is essential that the grafts be placed in the proper position in the sinus tarsi in order to prevent eversion and lateral displacement of the calcaneus (Fig. 2). Usually the most stable position is obtained by placing the grafts in a slightly oblique position, so that the lower ends of the grafts in contact with the calcaneus are anterior to the upper ends. With the grafts in this position, they are almost at right angles to the axis of motion of the subtalar joint and effectively block the lateral displacement of the calcaneus. If the grafts are tilted backward as they pass from the talus to the calcaneus, they will move

FIG. 1-C

FIG. 1-D

Fig. 1-C: Lateral roentgenogram of the weight-bearing foot made on February 7, 1953, before the operation. The talus was in plantar flexion, and the calcaneus was everted and was displaced posteriorly.

Fig. 1-D: Lateral roentgenogram made on February 10, 1953, after extra-articular arthrodesis of the subtalar joint with bone grafts. The relation of the calcaneus to the talus was improved, but the calcaneus was still posterior to the talus. The grafts had been poorly placed in the sinus tarsi.

FIG. 1-E

FIG. 1-F

Fig. 1-E: Roentgenogram made three months after fusion. There was further loss of position in spite of manipulation. The grafts did not lock the calcaneus beneath the talus.

Fig. 1-F: Roentgenogram made twelve weeks after the revision of the arthrodesis and transplantation of the peronaeus brevis to the talonavicular region. Plantar flexion of the talus was corrected. The calcaneus was displaced forward beneath the talus; the height of the foot was restored.

Fig. 1-G: Anteroposterior roentgenogram. The calcaneus was laterally displaced and was posterior to the talus. Abduction of the fore part of the foot resulted.

Fig. 1-H: Anteroposterior roentgenogram made after revision of the arthrodesis. The calcaneus was in good alignment in relation to the talus. Abduction of the fore part of the foot was corrected.

FIG. 1-G

FIG. 1-H

with the calcaneus as it is displaced posteriorly in eversion. The grafts will thus become loose in the sinus tarsi. This is demonstrated in Figures 1-D and 1-E. A minimal amount of cortical bone should be removed from the inferior aspect of the talus and the superior aspect of the calcaneus, but the bed in which the grafts fit should be squared off at the corner margins so that the bone grafts will fit in securely and will not be displaced. The grafts should be

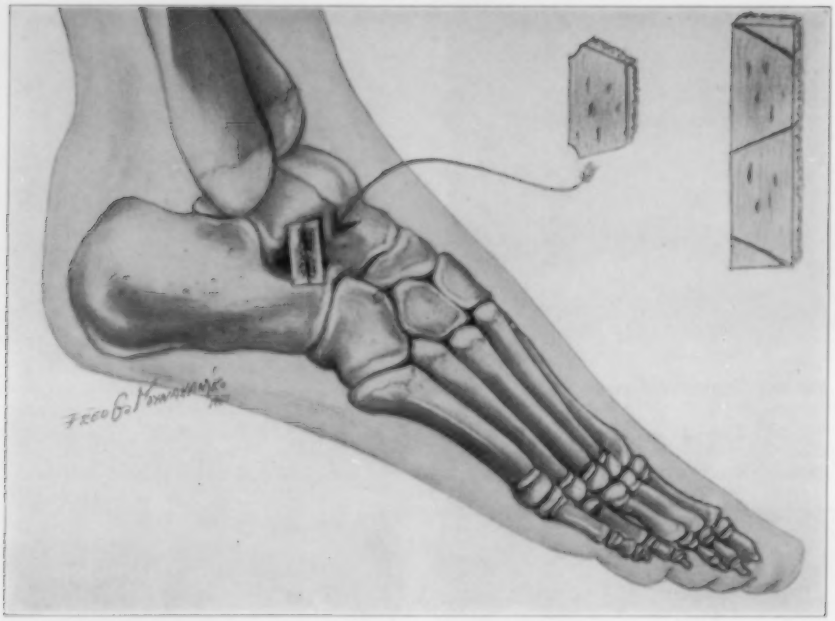


FIG. 2

Drawing shows the placing of the grafts in the sinus tarsi at right angles to the axis of motion through the subtalar joint. (Correction of Fig. 4 from *The Journal of Bone and Joint Surgery*, **34-A**: 933, Oct. 1952.)

placed into the sinus tarsi with the foot held in an overcorrected position. The foot should then be everted to a neutral position in order to lock the grafts securely in place. It must be borne in mind that the bone in paralytic feet in young patients is very soft, and the grafts should not be placed within the cancellous bone because they might compress further up into the body of the talus and the calcaneus. The outer margin of the graft should rest against the cortex of the talus and the calcaneus. The foot should not be held in an overcorrected position postoperatively since this position would lead to the development of a varus deformity. When the calcaneus has been correctly placed beneath the talus, the plane of the talonavicular joint and the calcaneocuboid joint are almost in line. If the distal end of the calcaneus lies posterior to the talonavicular joint, there will be a valgus deformity, and, if the calcaneus is anterior to the distal end of the talus, there will be a varus deformity. These findings can be determined at operation and confirmed by roentgenograms made after the operation. If the grafts are placed in a squared bed in the sinus tarsi, rather than in slots, minor adjustments in position can be accomplished at the time of a cast change in the postoperative period. However, if satisfactory position cannot then be demonstrated by roentgenograms, it would seem advisable to re-operate and to place the grafts correctly. This should be a simple procedure if it is done within ten to fourteen days after the operation.

Inadequate Correction

In two instances, solid fusion occurred; but the calcaneus had not been placed far enough medially beneath the talus at the time of operation, and the deformity was inadequately corrected. In both instances, residual eversion of the heel and abduction of the fore part of the foot persisted, so that, although with weight-bearing the foot was improved, there was still some residual deformity (Figs. 3-A and 3-B). In one of these patients, with bilateral deformity, a good result was obtained on the left side;

Fig. 3-A: Case B. W., February 10, 1950, at the age of nine years. There was pronation bilaterally. The tibialis anterior and the tibialis posterior of the left leg were paralyzed; the tibialis posterior of the right leg was also paralyzed. The tibialis anterior on the right was rated *good*.

Fig. 3-B: Photographs made on April 6, 1954, three years after operation on the right foot and four years after operation on the left foot. There was residual deformity of the right foot because of the inadequate correction of the position of the calcaneus beneath the talus at operation. A good weight-bearing foot resulted on the left.

there was inadequate correction on the right side.

FIG. 3-A

B. W., male, had acute poliomyelitis in 1945 at the age of five years. There was residual paralysis of the tibialis anterior and tibialis posterior and of the left quadriceps. The other muscles of the left leg were rated *fair plus* or better. In the right leg there was paralysis of the tibialis posterior but the tibialis anterior was rated *good* and the peroneals were normal. Valgus deformity of moderate degree developed. In May 1947, the peronaeus longus was transplanted to the base of the first metatarsal of the left foot. Good dorsiflexion was obtained, but the foot became progressively flatter (Fig. 3-A). In 1950, five years after the onset of poliomyelitis, an extra-articular subtalar arthrodesis was done. It was difficult to maintain the calcaneus beneath the head of the talus anteriorly; therefore a screw was placed across the head of the talus and the anterior portion of the calcaneus. A good weight-bearing foot resulted (Fig. 3-B).

FIG. 3-B

In July 1951, an extra-articular arthrodesis was done on the right foot. Roentgenograms made after the operation showed that the calcaneus had not been adequately placed beneath the talus, and the fore part of the foot remained in abduction. The foot was improved by the operation, but there was some residual deformity.

Recurrent Deformity with Marked Equinus

Among the patients treated early in the series, there were three patients with complete recurrence of the deformity, in spite of apparent adequate replacement of the calcaneus beneath the talus. In all three of these patients a severe equinus deformity had been present preoperatively and could not be corrected at the time of the extra-articular fusion of the subtalar joint. The fusion remained solid, but the talocalcaneal bone mass became displaced into valgus deformity within the ankle mortise. It is our impression at the present time that when there has been marked equinus deformity of the talus, with lateral displacement of the calcaneus, fusion of the subtalar joint with bone grafts will not provide a permanent correction of the deformity. The immediate postoperative correction may be excellent, but it will not be maintained. If recurrence of the deformity is to be prevented, it is necessary to correct the equinus deformity and to provide some support for the talonavicular area which is analogous to the force of the tibialis posterior. All three of these patients had severe valgus deformities and a tight heel cord, associated

FIG. 4-A

FIG. 4-B

FIG. 4-C

Fig. 4-A: Case D. H., January 28, 1950, at the age of six years. There was severe paralytic flat-foot, with a tight heel cord. Extra-articular arthrodesis of the subtalar joint was done on May 29, 1950. No transplantations were done because of the equinus deformity.

Fig. 4-B: Photographs made on April 13, 1951. There was recurrence of the deformity and tightness of the heel cord.

Fig. 4-C: Photographs made on April 15, 1954, four years after the operation. There was no recurrence after correction of the equinus deformity and transplantation of the peronaeus brevis to the talonavicular area in May 1951.

with complete paralysis of the tibialis posterior. Of the three patients who had recurrence of deformity, no transplantation was done in two, and in the third the peronaeus longus was transplanted forward into the second metatarsal. In one of the patients, after the deformity had recurred, the heel cord was stretched by means of a series of wedging casts until the equinus deformity of the talus was corrected. The peronaeus brevis was then transplanted beneath the talonavicular joint and was inserted into the navicular. The deltoid ligament was tightened. In this patient, the deformity was corrected; the correction has been maintained since the secondary procedure.

D. H., male, had poliomyelitis in 1946 when he was two years old. There was complete paralysis of the tibialis anterior and the tibialis posterior. The gastrocnemius was rated *fair plus* and the peroneals were rated *good*. The left foot was supported with a plate and a short leg brace and an inner T strap. A bivalved cast was used at night to keep the foot inverted. A severely pronated foot developed with a tight heel cord (Fig. 4-A). In May 1950, an extra-articular subtalar arthrodesis was performed. Good alignment of the calcaneus and the talus was obtained, but the equinus deformity was not corrected. Tendon transplantation was deferred because of the equinus deformity and because it would have interfered with the child's attendance at school. He wore a brace and a modified Whitman plate, but the deformity recurred (Fig. 4-B). In April 1951, the equinus deformity was corrected by means of a wedging cast. In May 1951, the deltoid ligament was tightened and the peronaeus brevis was transplanted beneath the talus and was inserted into the navicular. Correction has been maintained (Fig. 4-C). Lengthening of the Achilles tendon and a posterior capsulotomy of the ankle joint might have made this correction easier, but it might have weakened the

FIG. 5-A

Case F. C., March 1, 1949, at the age of nine years. Photographs were made two years after transplantation of the tibialis posterior and the peronaeus brevis to the calcaneus. There was severe valgus deformity.

FIG. 5-B

Photographs made on May 5, 1954, five years after extra-articular arthrodesis of the subtalar joint. There was an excellent weight-bearing foot and good function.

gastrocnemius enough to impair the patient's take-off in walking. In spite of the fixed equinus deformity of the foot, the gastrocnemius was rated only *fair plus*.

This combination of the transplantation of the peronaeus brevis or peronaeus longus to the talonavicular joint and extra-articular subtalar arthrodesis has been performed upon sixteen other patients and has seemed to be an important factor in preventing recurrence of the type reported.

It has been our experience that, in the majority of patients with minor tightness of the heel cord, correction can be obtained at the time of operation. It is difficult to correct the equinus deformity of the talus preoperatively with wedging casts because the force necessary to maintain the calcaneus beneath the talus produces skin difficulties. Once the calcaneus has been fixed beneath the talus, however, pressure can be exerted upon the talus to restore it to its normal position in the ankle mortise. In the event that the equinus deformity cannot be corrected at operation, the grafts are allowed to become consolidated, and, about four to six weeks after operation, the foot is wedged up into dorsiflexion. If the equinus deformity is so marked that it seems unlikely that correction can be obtained with a wedging cast, a heel-cord lengthening and posterior capsulotomy of the ankle joint should be considered. In none of the poliomyelitic patients in this series was the heel cord lengthened, but in one patient, previously mentioned, it might have been indicated. Lengthening of the Achilles tendon has been performed for correction

of equinus deformity in patients with cerebral palsy who have had extra-articular subtalar arthrodesis for correction of severe valgus deformities.

Overcorrection

Although unsatisfactory results have been largely due to the fact that the flat-foot was inadequately corrected at the time of surgery or that the muscle imbalance was not sufficiently improved, there have been four patients in whom the deformity was overcorrected. This produced a varus deformity. In two of these patients, the overcorrection was severe enough to warrant a revision.

FIG. 6-A

Case B. H., July 3, 1952, at the age of thirteen years. The onset of poliomyelitis was at eleven years. There was complete paralysis of the left leg. Other muscles were rated *good* or better.

One of these patients was a thirteen-year-old girl (B. H.) who had complete paralysis of her left leg (Fig. 6-A). Subtalar arthrodesis was performed in conjunction with a posterior bone block. Her foot was fixed in only slight inversion, but it was very disabling because of drop-foot. A callus developed beneath the head of the fifth metatarsal (Fig. 6-B). Revision of the arthrodesis is planned.

In two other patients the inversion of the foot was not

FIG. 6-B

Photographs were made on May 5, 1954, twenty months after extra-articular subtalar arthrodesis and posterior bone block. The deformity was overcorrected. There were slight varus deformity of the heel, adduction of the fore part of the foot, and a callus beneath the fifth metatarsal head. The foot will need revision.

marked enough to be disabling; it may subsequently give rise to discomfort as a result of abnormal weight-bearing. It has been previously stressed that the calcaneus should be displaced medially beneath the head of the talus at the time of operation. However, if it is necessary to place the fore part of the foot in adduction or the calcaneus into inversion in order to accomplish this replacement, it is advisable to accept a little less correction and to avoid the difficulties of producing talipes varus. This is particularly true in older patients in whom the architecture of the foot is more fixed and less adaptation can take place. In two patients, varus deformity developed after the operation because the pero-

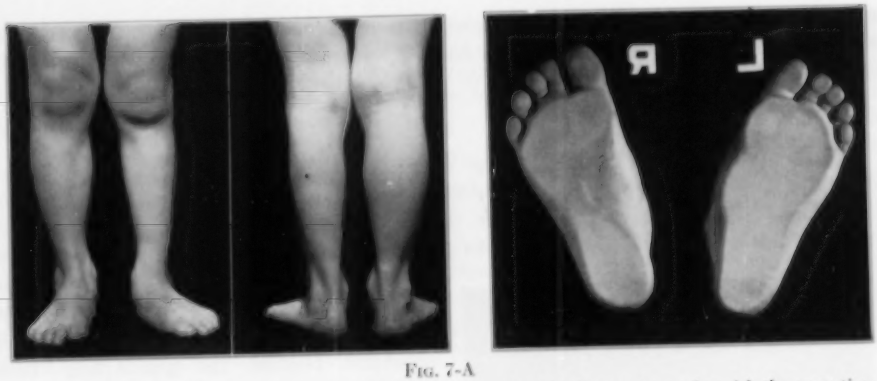


FIG. 7-A

Case P. M., May 9, 1952, at the age of four years. The patient had normal muscles with the exception of the tibialis anterior and tibialis posterior which were completely paralyzed.

FIG. 7-B

Photographs were made on November 17, 1953, one year after the extra-articular subtalar arthrodesis, with homogenous bone grafts, and transplantation of the peronaeus brevis to the talonavicular area. There was excellent correction of the deformity, but the bone grafts were absorbed in the mid-portion. There was no discomfort.

FIG. 7-C

FIG. 7-D

Fig. 7-C: Lateral roentgenogram of the weight-bearing foot. The talus was in plantar flexion. As the calcaneus was everted, it was displaced posteriorly. The sinus tarsi was obliterated.

Fig. 7-D: Roentgenogram made eighteen months after extra-articular subtalar arthrodesis, with homogenous bone grafts. Correction was well maintained and the foot was asymptomatic. The grafts appeared to be solid.

naeus brevis had been inserted beneath the spring ligaments into the talonavicular area and the fore part of the foot had been held in rather marked adduction. The subsequent contracture which developed in this area was a major element in the production of the deformity. The foot should not be put up in plaster in an overcorrected position. If the

operation has been well performed and the grafts have been securely placed in the sinus tarsi, the foot should be held in neutral position with a little tendency to bring the foot out into eversion so that the grafts will be under compression.

Non-Union and Absorption

Most interesting, on reviewing these cases, was the finding that union took place very rapidly and that the grafts were solidly incorporated into the talus and calcaneus within eight to ten weeks after operation. The average time when partial weight-bearing was allowed was from nine to eleven weeks after operation. There were only three patients in whom there was difficulty with union of the graft. Two of these patients were re-operated upon within six months after operation because the grafts had been incorrectly placed at the time of operation and the deformity had not been corrected. At re-operation, it was found that there was non-union of the grafts at the lower end where they had been inserted into the calcaneus. It appears that the grafts would

FIG. 7-E

FIG. 7-E

FIG. 7-F

Fig. 7-E: Ten weeks after extra-articular arthrodesis, the grafts appeared to be united to the adjacent bones. Weight-bearing was permitted at that time.

Fig. 7-F: Roentgenograms made two years after fusion and transplantation of the peronaeus brevis to the talonavicular area. The correction was maintained, and the foot was asymptomatic. The lateral roentgenogram showed absorption of the mid-portion of the grafts.

eventually have united, but the revision of the procedure was carried out before this occurred. In both feet, the grafts were re-inserted into the sinus tarsi; solid union occurred and excellent correction of the deformity resulted. In one of these patients, the second set of grafts was taken from bone-bank ribs, and union occurred in ten weeks.

The one instance of absorption which occurred in this series was in a four-year-old boy who had an extra-articular subtalar fusion in which homogenous grafts obtained from rib bone were used (Figs. 7-A and 7-C). The grafts became solidly incorporated at both ends and weight-bearing was allowed at ten weeks

(Fig. 7-E). Thus there was an excellent correction of the deformity, and the boy was permitted full activity without any apparent discomfort (Fig. 7-B). However, at follow-up examination two years after operation, it was observed that the mid-portion of the graft had been gradually absorbed and had not been replaced by continuous bone (Fig. 7-F). The boy had no apparent motion through his subtalar joint. It may be that this will eventually be bridged with solid bone.

Homogenous grafts were used in four patients, and, with the exception of the previously mentioned patient, union progressed uneventfully and weight-bearing was allowed in ten, eleven, and twelve weeks, respectively. Our limited experience with the use of homogenous bone does not permit us to draw valid conclusions, but the only instance of absorption of the graft occurred when homogenous bone had been used. It is a relatively simple procedure to obtain autogenous bone from the proximal portion of the tibia of the involved leg with the bone saw, and it adds so little time to the procedure that there would seem to be little occasion to use homogenous bone. Actually, there is an advantage in obtaining the grafts from a short extremity, inasmuch as stimulation of growth usually occurs following the removal of bone for grafting.

TENDON TRANSPLANTATION

Whenever possible, tendon transplantation should be done at the time of the extra-articular arthrodesis of the subtalar joint. In this series, twenty-two transplantations were done in conjunction with the arthrodesis. In fifteen patients, the transplantations were deferred because of the presence of an equinus deformity or because of the need to evaluate the effect of the fusion on the degree of imbalance. When the equinus deformity had been corrected by wedging casts during the postoperative period, it was possible to do the transplantation within six to eight weeks after the arthrodesis. In some instances, because of the problem of attendance at school, the arthrodesis was performed one summer and the transplantation was deferred until the next.

The type of transplantation has varied considerably (Table II), depending upon the severity of the deformity and the functional requirements of the foot. If there is complete paralysis of both the tibialis anterior and tibialis posterior and the deformity is severe, it is advisable to provide support for the talonavicular area. Transplantation of either the peronaeus brevis or the peronaeus longus beneath the neck of the talus and forward beneath the spring ligaments into the navicular has afforded excellent support to this area. This has been done in seventeen patients. This procedure, however, does not provide good dorsiflexion power, and, if the patient is in need of dorsiflexion rather than medial support, it is preferable to transplant the peronaeus longus into the base of the second metatarsal. This was the procedure of choice in eighteen patients. The flexor hallucis longus was transplanted into the tendon sheath of the tibialis posterior and beneath the talonavicular area to provide support; in one patient the tibialis anterior was transplanted into the posterior tibial sheath and beneath the talonavicular joint.

Extra-articular subtalar arthrodesis was done in five patients who had had posterior transplantations of the tibialis posterior and peroneal tendons. The feet were everted, but the arch was not depressed; the fusion was performed to provide lateral stability and to prevent increasing valgus deformities.

In one patient marked eversion developed two years after the tibialis posterior and peroneals had been placed back into the calcaneus (Fig. 5-A). With the progression of the valgus deformity, the effectiveness of the transplantation decreased. After extra-articular fusion of the subtalar joint, there was excellent correction of the deformity, and the patient was able to walk on tip-toe (Fig. 5-B).

The question has been raised whether the transplantation alone might correct paralytic flat-foot without the extra-articular subtalar arthrodesis. In seven patients in this series, transplantation without arthrodesis was performed to equalize muscle imbalance of the foot. The flat-foot was not corrected. Subsequently an arthrodesis was carried out, and excellent results were obtained.

TABLE II

TENDON TRANSPLANTATIONS

	No.
Tendon Transplantations	
Transplantations before arthrodesis	7
Transplantations with arthrodesis	22
Transplantations after arthrodesis	15
No transplantations	8
Type of Transplantation	
Peronaeus brevis to talonavicular area	10
Peronaeus longus to talonavicular area	7
Peronaeus longus to second metatarsal	18
Peronaeus longus to first metatarsal	1
Peronaeus brevis and peronaeus longus to calcaneus	5
Other transplantations	3

Of the entire group of fifty-two patients in whom extra-articular subtalar fusion was done, only eight patients did not have tendon transplantation. In six of the patients, there was nothing available for transplantation. In one patient an ankle fusion and in another a posterior bone block were done as supplements to the subtalar arthrodesis. In only two of the patients who had no transplantation were there muscles available for transplantation; in both instances it is probable that tendon transplantation would have prevented the recurrence of the deformity.

SUMMARY

In the original presentation of this operation, it was stated that the correction of the paralytic flat-foot evolved into a problem of obtaining several major objectives. The calcaneus must be replaced beneath the talus and must be maintained in a normal relation to it. The talus must be brought out of equinus deformity. Muscle balance should be restored by muscle transplantation in order to avoid recurrence. The deforming everting power of the peroneal muscles should be removed, and active inversion and dorsiflexion should be restored to the talonavicular area. Since it is desirable to correct the deformity in a child before it becomes fixed, the operative technique should not interfere with the growth of the foot. After a review of the fifty-two patients who had been operated upon, it was apparent that adherence to these fundamental principles will give satisfactory results in the management of the paralytic flat-foot. Failures have been due to inadequate replacement of the calcaneus beneath the talus, failure to correct the equinus deformity of the foot, inadequate correction of the muscle imbalance, and overcorrection of the deformity with a resultant talipes varus. As a result of the experiences we have had during the past nine years with this method, it can be stated that extra-articular fusion of the subtalar joint, with bone grafts placed in the sinus tarsi, can be performed quite easily and can provide adequate correction of paralytic flat-foot. In order to prevent recurrence in severely deformed feet, it is necessary to correct the equinus deformity of the foot and to restore support to the talonavicular area. This procedure is well adapted to use in the young child in the age group four to eight years in whom the deformity is progressing rapidly. The procedure can also be used as an alternate procedure to triple arthrodesis for the correction of valgus deformities in older patients. In feet that are of adult architecture and which display severe deformity, it will probably be impossible to restore the normal relationship of the calcaneus beneath the talus without resection of the subtalar joint. Therefore, a triple arthrodesis will be necessary. In the patients in this series, solid fusion was obtained in all in whom autogenous bone had been used. The one instance of absorption occurred in a patient in whom homogenous bone had been used. The height of the foot is restored by this procedure, and growth is maintained.

Fusion of the subtalar joint with autogenous bone grafts placed in the sinus tarsi is principally an extra-articular arthrodesis which does not interfere with the growth of the foot. If this procedure is carried out in combination with tendon transplantation to equalize muscle strength about the foot, a satisfactory correction of the deformity can be obtained. The insertion of the grafts in the sinus tarsi is a simple mechanical problem, and, if they are properly placed under slight compression, solid fusion and strong fixation of the subtalar joint should be obtained. Inadequate correction, insecure placement of the grafts, or overcorrection of the deformity will give poor results. This procedure is well adapted to the problem of paralytic flat-foot, but the same principles can be applied to the correction of the congenital planovalgus foot in which the talus is in marked equinus and to talipes valgus observed in cerebral palsy.

REFERENCES

1. Grice, D. S.: An Extra-Articular Arthrodesis of the Subastragalar Joint for Correction of Paralytic Flat Feet in Children. J. Bone and Joint Surg., **34-A**: 927–940, Oct. 1952.
2. Irwin, C. E.: Equinovalgus Deformity in the Immature Foot. Extra-Articular Subtalar Arthrodesis. Warm Springs Foundation Correspondence Club Letter. May 1954.

DISCUSSION

Mr. S. A. S. Malkin, Nottingham, England: Dr. Grice's paper describes what really amounts to a buttressing operation to prevent eversion of the calcaneus in patients in whom it is impossible to control this deformity by braces or other means. I think it has much to commend it, but I feel that, at least on theoretical grounds, it is important that the operation usually be combined with a muscle transplantation to the medial side of the foot. The operation is quite obviously an effective one if the correct technique is carried out. It should hold the talus and the calcaneus in a proper relationship to one another, while interfering little, if at all, with the growth of the foot. It uses a less important muscle to do the work of a more important muscle, and it reduces the work which the transplanted muscle is called on to do. The procedure observes general orthopaedic principles and should be very useful.

My experience with it is limited, but, having heard Dr. Grice's paper, I feel that it is an operation which will be carried out much more frequently in the future than it has been in the past.

Dr. W. M. Roberts, Gastonia, North Carolina: I thoroughly enjoyed reading Dr. Grice's first paper, which was published in 1952, and his present paper on further experience with this operation. He has answered some of the questions which I was going to ask him.

I would like to ask Dr. Grice why he hesitates to lengthen the Achilles tendon? Dr. Irwin in a Correspondence Club Letter has stated that Dr. Grice rarely lengthens the heel cord. I am at a loss to understand how he obtains such excellent results without this supplementary procedure. We have usually regretted not lengthening the Achilles tendon in any of the various flat-foot procedures in which we have had recurrences. We feel that our best results are in those patients in whom a minimal lengthening of the Achilles tendon was done. It is not necessarily an actual lengthening of the Achilles tendon; I cut the Achilles tendon in a position of lengthening, but I do not attempt to lengthen it at that time. I close the incision, and the tendon follows the foot as I correct the valgus deformity.

I would also like to have Dr. Grice describe in more detail the transplantation of the peroneals beneath the neck of the talus and forward beneath the spring ligaments.

Dr. Grice (closing): It has been a privilege to present this follow-up report on our experiences with subtalar arthrodesis. I have tried to stress the complications which might be encountered in performing this operation. It is not the only procedure which is applicable to paralytic flat-foot. It is an excellent procedure in properly selected cases.

Many paralytic flat feet with mild degrees of weakness in the tibialis anterior and tibialis posterior can be well supported with arch supports or braces. In many instances a tendon transplantation will restore muscle balance and will provide a good functional foot which has mobility through the mid-tarsal region. We select only those patients who have severe deformities or those in whom we anticipate the development of marked deformity because of severe muscle imbalance. As more experience with this operation is obtained, it may be found to have a wider application to the problem of the severely pronated foot related to congenital plantar flexion of the talus. We have done the procedure in a limited number of patients with this condition.

I am very grateful to Dr. Irwin for his Correspondence Club Letter concerning this procedure. I think that one of the patients in our series would have had a better result if we had corrected the equinus de-

(Continued on page 365)

THE USE OF RADIO-ACTIVE PHOSPHORUS (P^{32}) TO DETERMINE THE VIABILITY OF THE HEAD OF THE FEMUR *†

BY H. B. BOYD, M.D., D. B. ZILVERSMIT, PH.D.,
AND R. A. CALANDRUCCIO, M.D., MEMPHIS, TENNESSEE

From the Departments of Orthopaedic Surgery and Physiology, University of Tennessee Medical School, Memphis

THE PROBLEM

At present there is no method by which the surgeon can predict the development of avascular necrosis of the head of the femur at the time of operation for acute fracture of the femoral neck. The diagnosis of avascular necrosis is made either by roentgenographic examination or by histological examination. The roentgenographic diagnosis cannot usually be made until nine months to two years after the time of fracture. Histological examination is only practical in those instances in which the head of the femur has been removed.

If the surgeon could predict at the time of surgery in which patients avascular necrosis would probably develop, he could modify the operation and decrease the incidence of pain, disability, and the need for future reconstructive operations. The material presented in this paper is an experimental approach to the problem of predicting the viability of the head of the femur at the time of the acute fracture by means of the use of radio-active phosphorus (P^{32}).

Selection of Radio-Active Isotope and Geiger-Müller Tube

In 1949, Dr. F. L. Roberts ** suggested to the authors the possibility of using a radio-active isotope in order to determine the viability of the head of the femur. At that time we surveyed the available isotopes; radio-active phosphorus (P^{32}) was chosen because it has a suitable half-life (14.3 days), because it is a pure beta-ray emitter, and because it is a moderate bone seeker.

In order that counting rates could be obtained in the femoral head *in vivo*, a Geiger-Müller tube sensitive to beta radiation and small enough to be inserted into the head of the femur was required. The Geiger-Müller tube devised by Robinson in 1950 for the localization of brain tumors was found to be suitable. The probe portion is two millimeters in diameter (the same as that of the guide wire used to insert a cannulated Smith-Petersen nail) and ten centimeters long. The distal five millimeters of the tube, as shown in Figure 1, are not sensitive to radiation; the thirteen millimeters proximal to this area are sensitive.

Absorption of P^{32} Beta Radiation by Bone

In order to ascertain that only the P^{32} of the femoral head was measured without interference from radio-active sources in the surrounding soft tissues, we calculated the volume around the sensitive portion of the Geiger-Müller probe from which beta radiation was being received. Two factors enter into the calculation of the fraction of the total counts that are contributed by the first, second, and third millimeter annuli surrounding the Geiger-Müller probe: (1) the distance of the P^{32} sources from the center of the sensitive volume and (2) the absorption of the beta rays by the intervening bone. The absorp-

* Read at the Annual Meeting of The American Orthopaedic Association, Bretton Woods, New Hampshire, June 8, 1954.

† This investigation was supported in part by a research grant (8-265) from The National Institute of Arthritis and Metabolic Diseases of the National Institutes of Health, Public Health Service, and a fund from The Campbell Foundation.

** Associate Dean, University of Tennessee Medical School.

tion of beta radiation from P^{32} by water was measured by Wu, in 1941, who found a half-thickness * of approximately one millimeter. The density of cancellous bone from the head of the femur (including marrow elements) was found to be 1.2. Actual measurements with various thicknesses of fresh bone used as absorbers between a P^{32} source and a Geiger-Müller tube gave a half-thickness of 0.75 millimeters. Using this latter figure and combining it with the distance factor, we calculated that 65 per cent. of the total counting rate was contributed by the first millimeter annulus around the Geiger-Müller probe, with rapidly decreasing amounts contributed by annuli at greater distances. Chart I shows the contribution of radiation to the Geiger-Müller probe from distances up to seven millimeters away from the center of the tube. The results show that

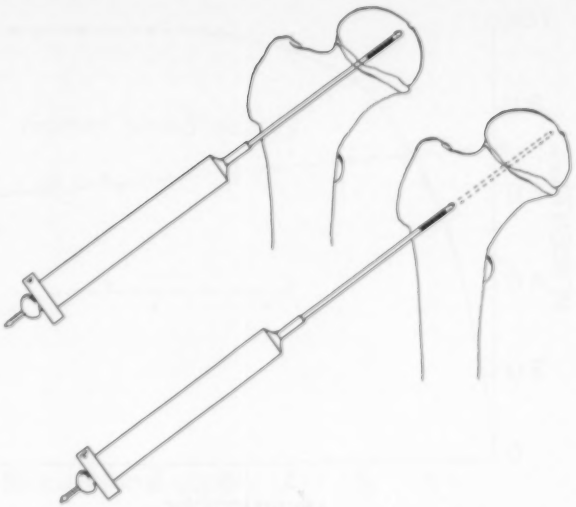


FIG. 1

Location in the head and the trochanter from which the counts are recorded. Darkened area of the tube shows the sensitive portion.

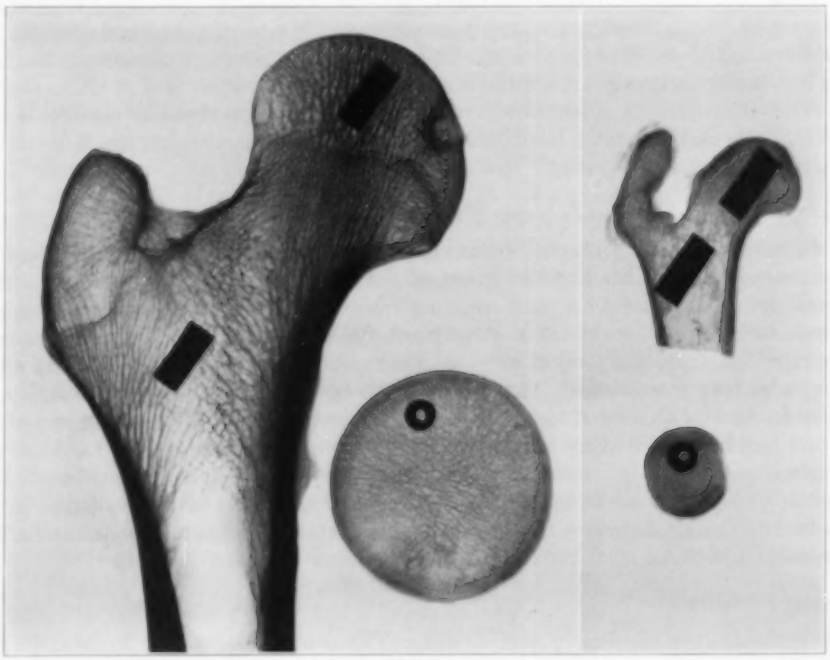


FIG. 2

Volume of bone from which approximately 90 per cent. of the radiation is recorded in the human femur and the dog femur.

* The half-thickness of a substance is the thickness which will absorb half the radiation.

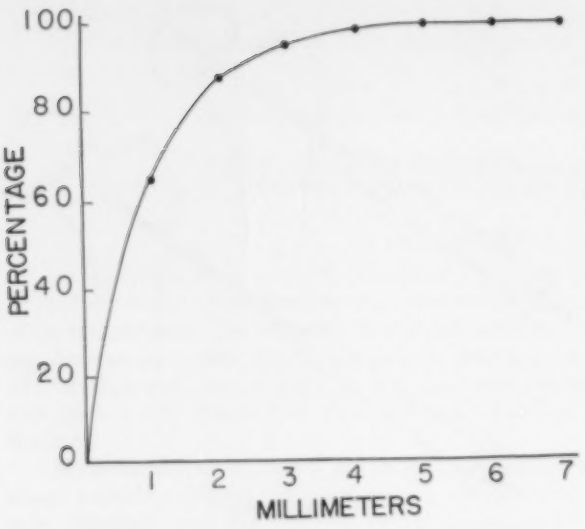


CHART I

Accumulative percentage of total counts derived from the first to the seventh one-millimeter annuli of bone.

for all practical purposes the radio-activity measured by the Geiger-Müller probe is derived from the first three millimeters surrounding the sensitive portion of this probe. Thus the probe is satisfactory for obtaining counting rates in the head and trochanter of the femur. In Figure 2 the relative volume of bone from which counts were obtained in the head of the human femur and the head of the dog femur is seen.

DOG DATA

The ideal tracer dose of P^{32} is the smallest amount that will produce counting rates of suitable magnitude. Four microcuries of P^{32} per pound of body weight was injected intravenously into dogs, and the counts were recorded from the head and trochanter. These counts ranged from 200 to 1,000 counts per minute. Since counting rates of half this amount would be adequate, two microcuries of P^{32} per pound of body weight was considered the proper dose for patients. This amount of radio-active phosphorus has been used in other investigative work without known harm to the patient and produces slightly less than two roentgens of total body radiation.[10] This is approximately one-fifteenth of a single dose of P^{32} used in the treatment of polycythaemia vera, in which treatment the dosage is usually repeated.[5]

The Proper Interval between Injection of P^{32} and the Recording of Counting Rates

By means of guide wires and with roentgenographic control, the Geiger-Müller tube was inserted into the head of the femur of a dog. Radio-active phosphorus was then injected into a forelimb vein, and counting rates were determined at five-minute and ten-minute intervals for a total of three hours (Chart II). For the first thirty minutes after injection, there was a rapid increase in the radio-activity, but, after one and a half hours, a plateau was reached. This was true for bone with impaired blood supply, as well as for bone with normal blood supply. Since the amount of P^{32} increases rapidly in the first half hour after injection, ratios between the counting rates in the head and the trochanter should not be recorded during this period. After the plateau has been established, the counting rates in the head and trochanter vary little with the increase in the time factor. The ideal time to record the counting rates is approximately one and a half hours after injection.

Index of Viability

Trochanter-to-head ratio of radio-activity: The present study was founded on the belief that avascular necrosis is a result of diminished blood supply to the femoral head due to the trauma *per se* and to the management of the fracture. It is felt that the relative amount of radio-activity in the head of the femur after the injection of P^{32} is an index

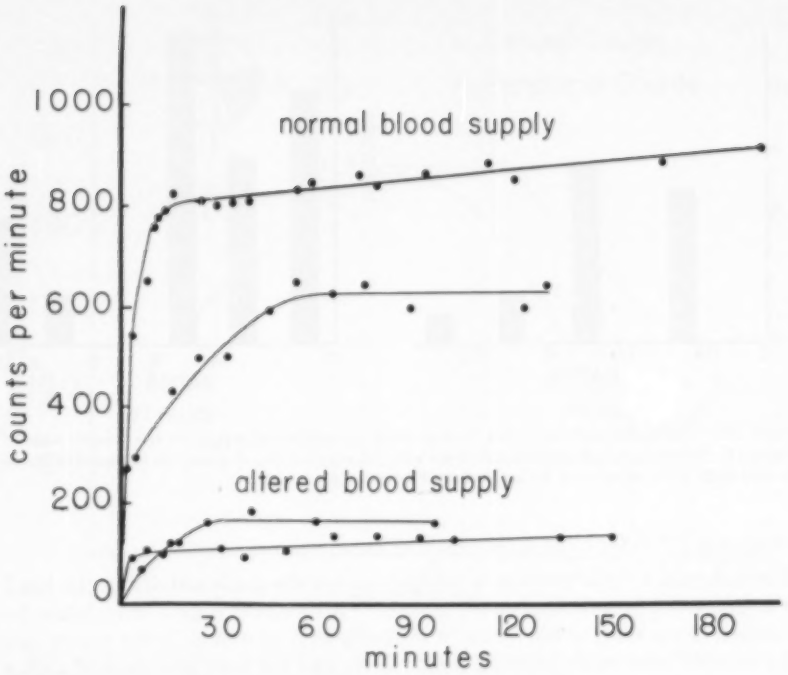


CHART II

Curves illustrating distribution of P^{32} in the heads of dog femora, with normal and altered blood supplies, at varying intervals of time following the injection of P^{32}.

of the viability of the bone. The numerical value of the counting rate in the head varies with the dosage and with other factors. On the other hand, the ratio of the counting rate in the trochanteric area to that in the head eliminates these irrelevant variables.

Trochanter-to-head ratios of radio-activity in dogs with normal blood supply to the femoral head: A guide wire was passed from the subtrochanteric region into the head of the femur. The guide wire was then removed and the Geiger-Müller tube was inserted. Care was taken to place the Geiger-Müller tube at the same depth as the guide wire, and counts per minute were recorded from the head, as well as from the trochanteric area. The trochanter-to-head ratio of radio-activity was determined in sixteen dogs and was found to vary from 0.8 to 2.3, with an average of 1.3, as noted in Chart III.

Trochanter-to-head ratios of radio-activity in dogs with partial interruption of blood supply to the femoral head: In fifteen dogs, the blood supply was interrupted by cutting the ligamentum teres, by stripping the capsule in various degrees, by dislocating the hip, and, in some cases, by osteotomizing the neck of the femur. Stripping of the capsule was done by removing the capsule from the anterior aspect of the acetabulum and by stripping the periosteum of the base of the neck and the capsule at the trochanteric area in varying degrees. The trochanter-to-head ratios of radio-activity varied from 1.3 to 32.0 (Chart IV). In a series of three dogs, the capsule was stripped slightly, moderately, and more completely. The ratios were 1.6, 3.3, and 4.9, respectively.

Because of the size of the femoral head of the dog, the area from which the counts were recorded extends into the neck of the femur. Therefore, we feel that no definite conclusions can be drawn from these data. They do, however, show that an interruption of the blood supply to the head of the femur does make the ratios vary.

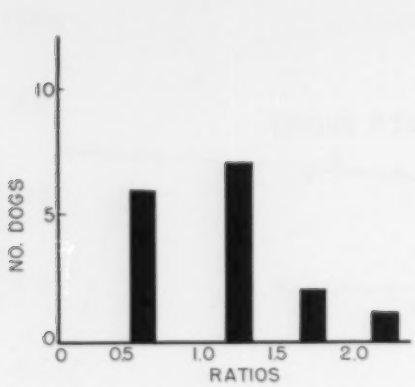


CHART III

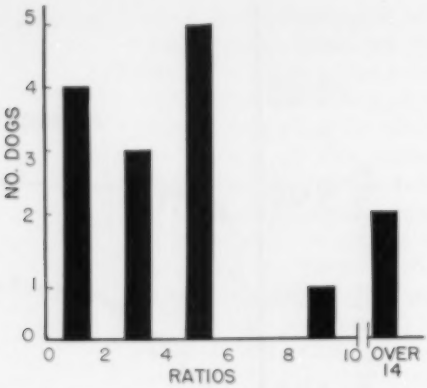


CHART IV

Chart III: Trochanter-to-head ratios in dogs with normal blood supply to the femoral head.
Chart IV: Trochanter-to-head ratios in dogs with interrupted blood supply to the head of the femur. (The two dogs with ratios over 10 had ratios of 14 and 32.)

Distribution of P^{32} in the Head of the Femur of Dogs

Fundamental to this problem is whether or not the radio-activity in the head of the femur is deposited in a homogeneous manner. End-window counts were taken from the cross section of the head of the femur in the periphery, as well as in the central area (Fig. 3). The sections were made at room temperature and the bone was cleaned with a brush before counts were taken. Peripheral counts were taken from sixteen heads with normal blood supply. An analysis of variance showed that the counts per minute from the anterior-inferior segment were significantly higher than those from the superior-posterior segment. The central counts were treated in a similar manner, and analysis of these data revealed a distribution which paralleled the peripheral count pattern. Chart V is the graphic representation of the distribution of the mean values of the peripheral and central counts. In order to facilitate comparison with clinical data, the femoral heads of the dogs were divided into areas in reference to the superior or maximum weight-bearing surface. It is of interest that the superior or weight-bearing areas were found to have a lower degree of radio-activity than the rest of the head.

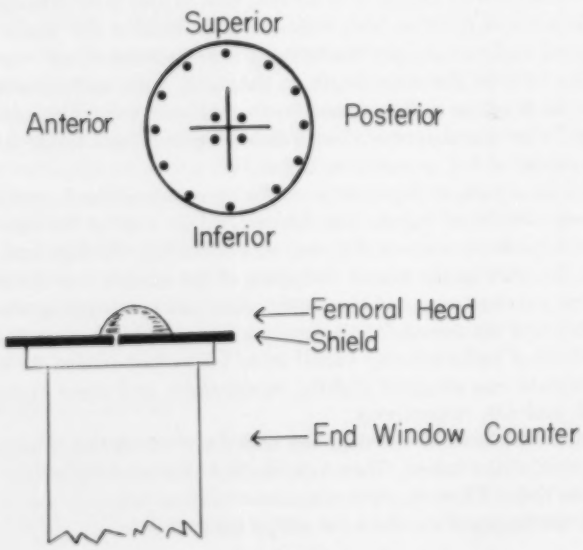


FIG. 3

Fig. 3: Upper portion indicates location from which counting rates were obtained from cross sections of the femoral head. The lower portion is a diagram of the end-window counter, the lead shield, with a two-millimeter hole, and a section of the femoral head in the proper location to secure a peripheral counting rate.

CLINICAL APPLICATION

Two microcuries of P^{32} per pound of body weight was injected intravenously in pa-

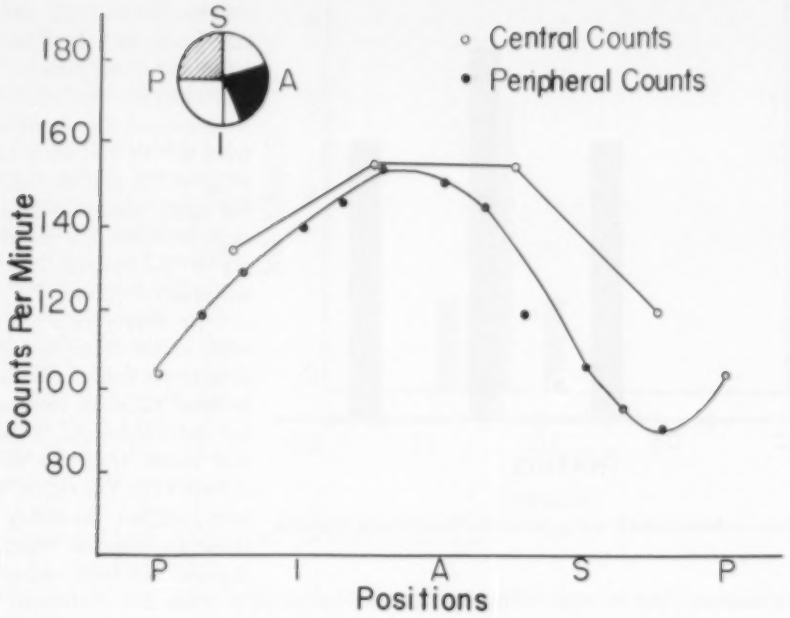


CHART V

Mean values of peripheral and central counts. Dark area indicates segment of higher counting rates and shaded area indicates segment of lower counting rates.

tients with fractures of the femoral neck, approximately one and a half hours before the counts were taken. The tubes and a radio-active sample were sterilized in solution, and the connecting cord was autoclaved. Shortly before the internal fixation of the hip, the Geiger-Müller tube was connected to the counting-rate meter and was tested with the radio-active sample. A guide wire, two millimeters in diameter, was used for the insertion of the Smith-Petersen nail. An attempt was made to place a second guide wire of the same diameter in the weight-bearing area. Roentgenograms were made to check the position of the guide wires. The guide wire in the most suitable position was removed, and the probe counter was inserted to the proper depth to record counting rates in the femoral head. The probe was partially withdrawn, and the counting rate was determined in the trochanter at a depth of approximately 3.5 centimeters. The determination of a single counting rate required approximately two minutes if there were no difficulties with the equipment or in the placement of the guide wires. To conserve time the counting rates were often determined while the roentgenograms were being developed. If the connecting cord is used too soon after autoclaving, the moisture content of the insulating material may prohibit the obtaining of counting rates. In fifteen patients it was not possible to determine ratios, because of mechanical difficulties. The counting-rate meter must be grounded, and the Geiger-Müller tube must not be recording while roentgenograms are being made or during the use of the electrocautery. Counting rates were obtained in more than one area of the head of the femur in twenty-two cases. It is now felt that, when possible, readings should be taken in the weight-bearing portion of the head where avascular necrosis occurs.

Adequate clinical data have been obtained from fifty-three patients (thirty-two patients with acute fractures of the femoral neck, ten with trochanteric fractures, ten with old fractures, and one with traumatic dislocation of the hip).

Since avascular necrosis does not develop in patients with trochanteric fractures, counting rates were recorded in these patients in order to ascertain the relatively normal

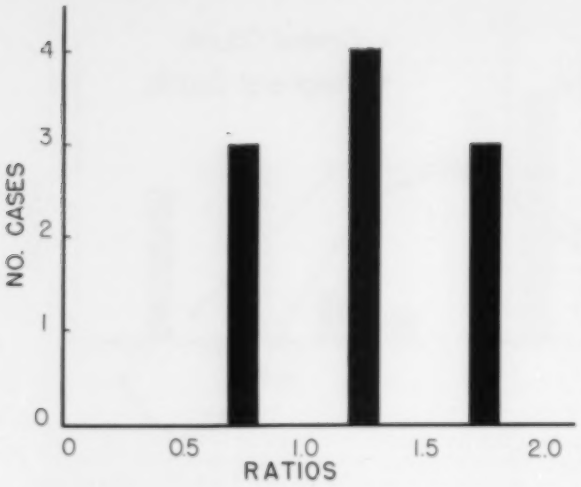


CHART VI
Trochanter-to-head ratios in ten patients with trochanteric fractures.

trochanter-to-head ratio of radio-activity. In Chart VI the data from patients with trochanteric fractures are summarized. These ratios vary from 0.7 to 1.9, with an average of 1.3, and are comparable with those obtained in dogs in which the blood supply of the femoral head was unimpaired (Chart III).

In thirty-two patients with acute fractures of the neck of the femur, trochanter-to-head ratios of radio-activity were obtained. These ratios varied from 1.3 to 16.7 (Chart VII). The ratios, therefore, compare favorably with those in dogs in which the capsule had been stripped in varying degrees. The average follow-up has been too short to make any statement as to the correlation between the ratios and the clinical results. In one patient with a fresh fracture of the neck of the femur a trochanter-to-head ratio of 3.2 was obtained. (Counts from the femoral head were obtained from the lower portion of the head.) This patient has been followed for two and one-half years, and avascular necrosis has developed in the weight-bearing portion. If the counts had been taken in the weight-bearing portion of the

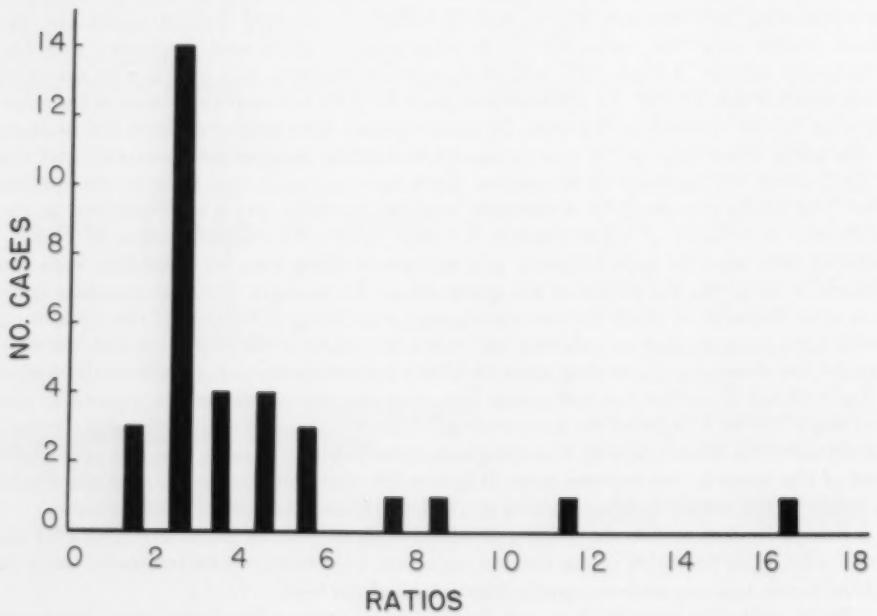


CHART VII
Trochanter-to-head ratios in thirty-two patients with acute fractures of the neck of the femur.

head, the ratio might have been higher (Chart V) and thus the diagnosis of avascular necrosis might have been anticipated.

In eight patients with old fractures in whom there were varying degrees of avascular necrosis, with or without union, trochanter-to-head ratios were obtained, and the removed heads were made available for study. In these, the ratios varied from 1.4 to 17.5 (Chart VIII) and, with the exception of the 1.4 ratio, the range was from 4.7 to 17.5. In one patient with a ratio of 3.1 there was non-union, but the head appeared to be viable as seen by roentgenogram.

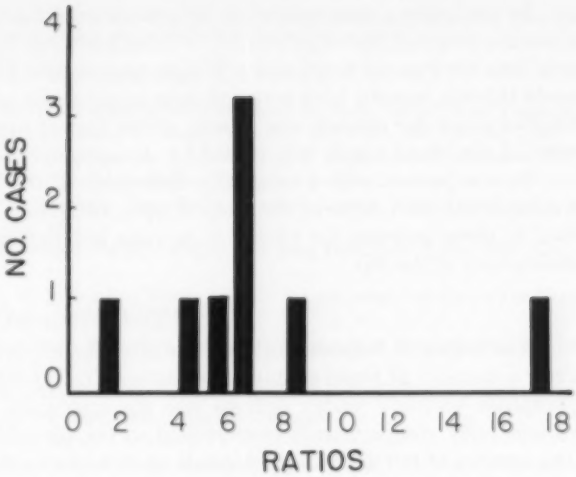


CHART VIII

Trochanter-to-head ratios in eight patients with known avascular necrosis of the femoral head.

Study of removed heads revealed that, in those heads with density and fragmentation, there were areas of obvious avascularity (with low counting rates), intermingled with areas of viable bone (with relatively high counting rates). The latter may have been areas of revascularization or areas in which the blood supply had been maintained. Some of the heads, which in the roentgenograms appeared to be dense or fragmented, were grossly avascular, and multiple readings produced uniformly low counting rates. The radio-autograms and trochanter-to-head ratios in two patients with avascular necrosis are illustrated in Figures 4-A and 4-B. The areas of avascularity revealed low counting rates and produced relatively little exposure of the radio-autograms.

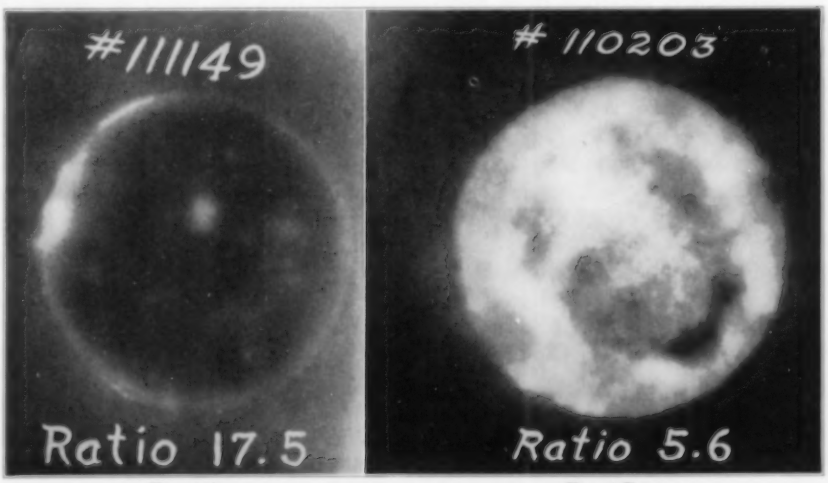


FIG. 4-A FIG. 4-B

Radio-autograms (positive) of femoral heads with known avascular necrosis.

Fig. 4-A: Complete avascular necrosis with a trochanter-to-head ratio of 17.5. The halo about the head is probably due to the absorption of P^{32} from the synovial fluid.

Fig. 4-B: Partially viable head with a ratio of 5.6.

In one patient with non-union of a fracture of the femoral neck, with questionable avascular necrosis, the ratio was 3.2. A bone graft was inserted from the subtrochanteric area into the femoral head, and a Blount type of osteotomy was done. Roentgenograms made thirteen months later revealed definite avascular necrosis. It is not possible to tell whether avascular necrosis was present at the time of surgery or whether further impairment of the blood supply was caused by the operation.

In one patient with a traumatic dislocation of the hip, it was possible to obtain a trochanter-to-head ratio at the time of open reduction. It is important to obtain more data in these patients, for avascular necrosis is a well recognized problem in traumatic dislocations of the hip.

DISCUSSION

The degree of radio-activity of bone after the intravenous injection of P^{32} is not entirely a measure of blood supply of the bone. The injected P^{32}, in the form of a buffered phosphate solution, readily diffuses into the interstitial fluid and is distributed in the various body compartments proportional to the phosphorus occurring naturally (P^{31}). The amount of P^{32} in the bone depends upon many factors, such as:

1. The amount of P^{32} in the blood;
2. The amount of diffusion of the P^{32} into the interstitial fluid;
3. The amount of exchange of interstitial P^{32} and P^{31} on the surface of the bone crystals;
4. The amount of P^{32} incorporated into bone by metabolism.

Therefore, the concentration of P^{32} in bone may vary with any of these factors and is not strictly a measure of circulation. In a matter of seconds after the intravenous injection of P^{32}, there is radio-activity in bone. The relatively high concentration of P^{32} shortly after injection suggests a surface ionic exchange rather than an enzymatic or metabolic process. At one and a half hours after injection there probably is an equilibrium established as to the amount of P^{32} and P^{31} on the surface of the bone crystals.[7]

The use of radio-active phosphorus to aid in the prediction of avascular necrosis of the femoral head was reported by Tucker in 1950. He removed biopsy specimens from the head and trochanter, and counting rates were determined from the ashed specimens. The ratios of radio-activity of the two locations ranged from 0.44 to 16.0. A preliminary report was given by Boyd and his associates, in 1951, of experimental work and the ratios obtained from the first five patients in whom direct counts were recorded. Arden and Veall, in 1953, reported radio-activity ratios from 0.6 to 30.0 in a series of patients in whom the biopsy method described by Tucker had been used.

The trochanter-to-head ratios of radio-activity of the thirty-two patients with acute fractures of the femoral neck in our series ranged from 1.3 to 16.7. Experience has shown that in approximately one third of the patients with complete fractures of the neck of the femur followed for more than one year avascular necrosis develops[3, 4, 6, 9]. Therefore, in the ten patients, approximately one third of this series, with the highest ratios—that is, 4.1 to 16.7—the prognosis would probably be poor. These ratios compare favorably with the ratios of 5.6 to 17.5 obtained in patients with known avascular necrosis.

In the patients with trochanteric fractures, the ratios were 0.7 to 1.9; therefore, in the twelve patients with ratios of 1.3 to 2.3, the prognosis would probably be good. No prediction can be made at this time concerning the ten patients with ratios of 2.5 to 3.9.

In pursuing this investigation, we have encountered a number of interesting problems which stimulate further study. Time may reveal that this method is of no value; however, it presents a new approach to an old challenge. We hope that this paper will encourage others to carry out similar projects so that a sufficiently large series of patients can be followed over a significant period of time in order to prove or disprove the value of this procedure.

NOTE: The authors wish to thank Miss Betty Houston, B.S., for her assistance in determining counting rates, in the collection and analysis of data, and in the preparation of the illustrations.

REFERENCES

1. ARDEN, G. P., and VEALL, N.: The Use of Radioactive Phosphorus in Early Detection of Avascular Necrosis in the Femoral Head in Fractured Neck of Femur. Proc. Roy. Soc. Med., **46:** 344–346, 1953.
2. BOYD, H. B.; ZILVERSMIT, D. B.; and CALANDRUCCIO, R. A.: The Use of Radioactive Phosphorous (P^{32}) in Determining the Blood Supply to the Head of the Femur. Cinquième Congrès International de Chirurgie Orthopédique, Stockholm, 21–25, mai 1951. Bruxelles, Imprimerie Lieleus, 1953 [Abstracted in J. Bone and Joint Surg., **33-B:** 475, Aug. 1951].
3. BOYD, H. B., and GEORGE, I. L.: Fractures of the Hip. Results Following Treatment. J. Am. Med. Assn., **137:** 1196–1199, 1948.
4. CLEVELAND, MATHER, and BAILEY, W. L.: An End Result Study of Intracapsular Fracture of the Neck of the Femur. Surg., Gynec., and Obstet., **90:** 393–405, 1950.
5. LAWRENCE, J. H.; BERLIN, N. I.; and HUFF, R. L.: The Nature and Treatment of Polycythemia. Studies on 263 Patients. Medicine, **32:** 323–388, 1953.
6. MCCARROLL, H. R.: Has a Solution for the Unsolved Fracture Been Found? Problem and Complications of Fractures of the Femoral Neck. J. Am. Med. Assn., **153:** 536–540, 1953.
7. NEUMAN, W. F.: Bone as a Problem in Surface Chemistry. *In* Metabolic Interrelations, Transactions of the Second Conference, edited by Edward C. Reifenstein, Jr., pp. 32–72. New York, Josiah Macy, Jr. Foundation, 1950.
8. ROBINSON, C. V.: Small Probing Geiger-Müller Counters. Rev. Scientific Instruments, **21:** 82–84, 1950.
9. SPEED, J. S.: Central Fractures of the Neck of the Femur. An Analysis of the End Results. J. Am. Med. Assn., **104:** 2059–2063, 1935.
10. TOBIAS, C. A.: Quoted by Lawrence, J. H.; Dobson, R. L.; Low-Beer, B. V. A.; and Brown, B. R.: Chronic Myelogenous Leukemia. A Study of 129 Cases in Which Treatment Was With Radioactive Phosphorus. J. Am. Med. Assn., **136:** 672–677, 1948.
11. TUCKER, F. R.: The Use of Radioactive Phosphorus in the Diagnosis of Avascular Necrosis of the Femoral Head. J. Bone and Joint Surg., **32-B:** 100–107, Feb. 1950.
12. WU, C. S.: The Continuous X-Rays Excited by the Beta Particles of P^{32}. Physical Review, **59:** 481–488, 1941.

DISCUSSION

DR. JOHN J. FAHEY, CHICAGO, ILLINOIS: The paper by Dr. Boyd, Dr. Zilversmit, and Dr. Calandruccio is very thought-provoking, and the value of kriowing the viability of the femoral head at the time of initial surgery is self-evident. The application of radio-active phosphorus to this problem was first reported by Tucker, in 1950, and later by Arden and Veall in 1953. These men removed biopsy specimens from the femoral head and used ashed samples of bone for their analysis, a procedure which is time-consuming and which may interfere with the bone strength and remaining blood supply. It cannot give the surgeon the answer at the operating table. Dr. Boyd, Dr. Zilversmit, and Dr. Calandruccio first reported, in 1951, a Geiger-Müller probe method for taking direct counts and have continued to explore the possibilities of this method. In various experiments, Dr. Boyd and his associates have determined the proper dose of the radio-active phosphorus, the optimum time for taking counts, and the relative vascular distribution within the femoral head of normal dogs. Since counts depend on many variables, the ratio-count method was devised to relegate the many variables to constants.

The trochanter-to-head ratio of radio-activity in normal dogs was consistently 2.3. Thus one finds that four of fifteen dogs (25 per cent.) with known disturbed blood supply had ratios that placed them in the normal group. Possibly the overlap of neck counts due to the large counter explains this.

If information on the effect of occluding various components of the circulation to the femoral head in experimental animals were available, evidence might be gained as to their relative importance. This in itself has been the basis of considerable investigative work.

If radio-active phosphorus were injected immediately after an intracapsular fracture of the neck of the femur and counts were made one and a half hours later, I suspect that the ratio would be similar to the ratios found by Dr. Boyd and his associates in their patients with femoral-neck fractures. Therefore, in such an instance, one would not expect the femoral neck to be dead, and such a count would indicate vascularity and not viability. Perhaps Dr. Boyd would comment on why he feels that lack of deposition of radio-active phosphorus indicates non-viability.

If femoral heads were removed early following intracapsular fractures of the neck of the femur and were analyzed by end-count methods, some information regarding segmental necrosis of the femoral head might be obtained.

The clinical investigation of these patients might itself yield the answers we are seeking.

(Continued on page 276)

RECONSTRUCTION OF HAND DIGITS BY TOE TRANSFERS*

BY PATRICK CLARKSON, F.R.C.S., LONDON, ENGLAND

From Guy's Hospital, London, and the Basingstoke Plastic Centre, Basingstoke, England

I wish here to describe very briefly some experiences in the late total reconstruction of digits by the use of transferred toes. This is an old method, introduced by Nicoladoni over fifty years ago. It fell into disrepute because of the uncertainty of the transfer. The uncertainty concerned both the viability of the toe on the hand and its subsequent function. Bunnell in his book reports that, in twenty of the first recorded transfers, most were stiff and had poor function.

I believe that the method of dorsal-flap transfer of a toe is a safe one and that useful function can be afforded the toe on the hand. It is the only method of complete digital reconstruction which will add a digit to the hand, which can provide movement within the restored part, and which will provide the part with a growing nail.

TECHNIQUE

The technique of transfer which I have adopted is accomplished in the following stages:

1. Preparation of the dorsal flap on the foot;
2. Attachment of the dorsal flap on the foot to the hand;
3. Attachment of tendons;
4. Detachment of the flap and toe from the foot;
5. Later remodeling.

1. *Preparation of the Flap*

A dorsal flap on the foot of at least one and one-half by one and one-half inches, based distally over the metatarsophalangeal joint of the toe to be transferred, has been

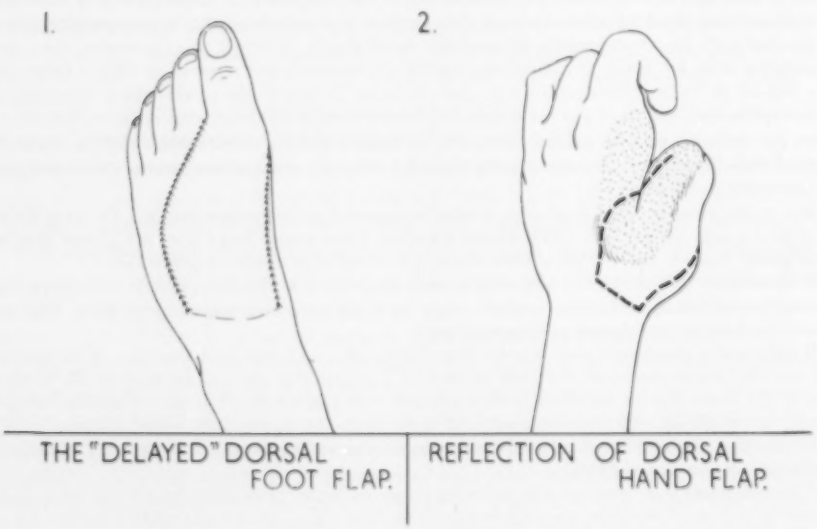
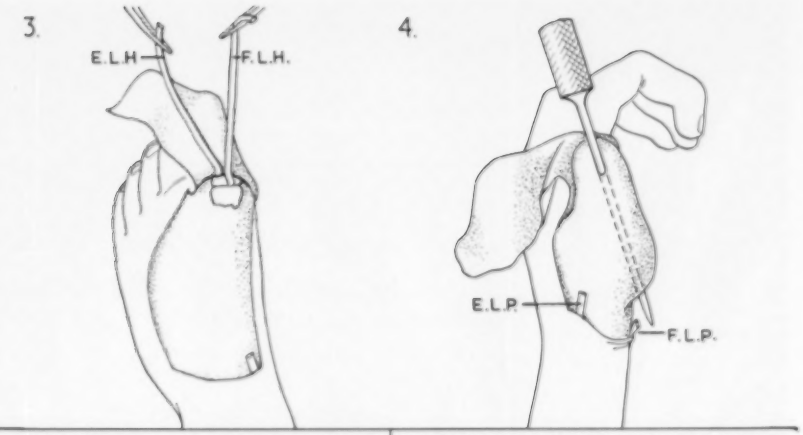


FIG. 1 FIG. 2

* Read at the Annual Meeting of the American Society for Surgery of the Hand, Chicago, Illinois, January 22, 1954.



ELEVATION OF DORSAL FOOT FLAP. WITHDRAWAL OF FLEX. LONG. HALL. THROUGH JOINT & SECTION OF EXT. LONG. H.

FIG. 3

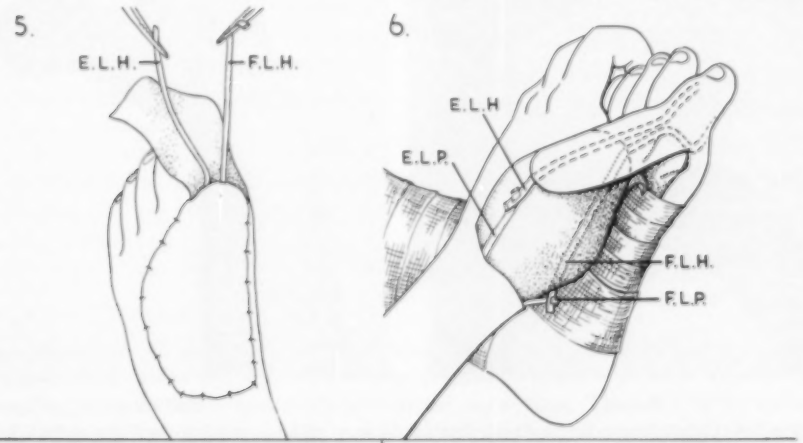
RECONSTRUCTION OF TUNNEL FOR TENDON OF FLEX. LONG. HALL. TO REACH THAT OF FL. LONG. POLL.

FIG. 4

used for single digit transfers. I have "delayed" this flap in one or two stages. For four-digit or five-digit transfers, I have used virtually the whole of the dorsum of the foot, again delaying the flap one or two times at two-week intervals. The larger the flap, the more secure from the mechanical point of view is the attachment of the hand to the foot. I have used the foot on the same side as the hand because it makes for easier nursing to have the arm along the outer side of the trunk and limb than to have it crossing the abdomen and pelvis.

2. *Attachment of the Flap*

The foot flap is elevated to its dorsal base at the toe or toes. The extensor tendons



SUTURE OF DERMATOME GRAFT TO DORSAL FOOT DEFECT.

FIG. 5

SUTURE OF EXT. LONG. HALL. TO EXT. LONG. POLL. AND OF FLEX. LONG. HALL. TO FLEX. LONG. POLL.

FIG. 6

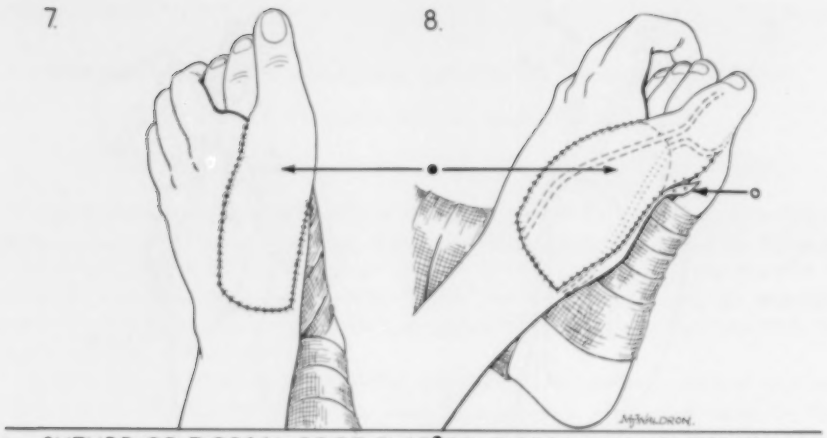

7.
8.
SUTURE OF DORSAL FOOT FLAP TO DORSAL HAND DEFECT
WITH DORSAL HAND FLAP LYING DEEPLY & TURNED OVER
DISTAL STUMP TO BE ATTACHED TO DERMATOME GRAFT.

FIG. 7 FIG. 8

are divided just distal to the ankle joint, and the dorsum of the foot is covered with a medium-thickness, dermatome-cut, split-thickness skin graft.

The hand is prepared as follows: The skin from the dorsum is deflected distally and

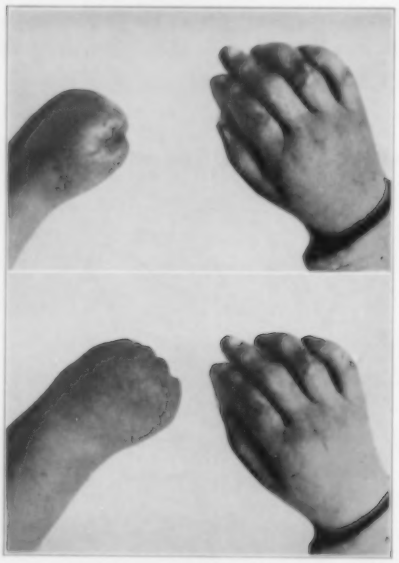


FIG. 9-A FIG. 9-B

Fig. 9-A: Case 1. Severe burns of both hands in infancy, with loss of all of the digits of the left hand beyond the stumps of the proximal phalanges and with syndactylia of these stumps including the thumb, produced a club hand.

Fig. 9-B: Photograph made after the transfer of the big toe and free grafts on the webs and palm. (The palmar graft was done by Sir Harold Gillies and a late flexor-tendon graft to the thumb was done by Mr. R. Furlong.) The grip is chiefly between the thumb and the longest finger stump (third finger). The patient can pick up a safety pin between these digits and can hold a glass.

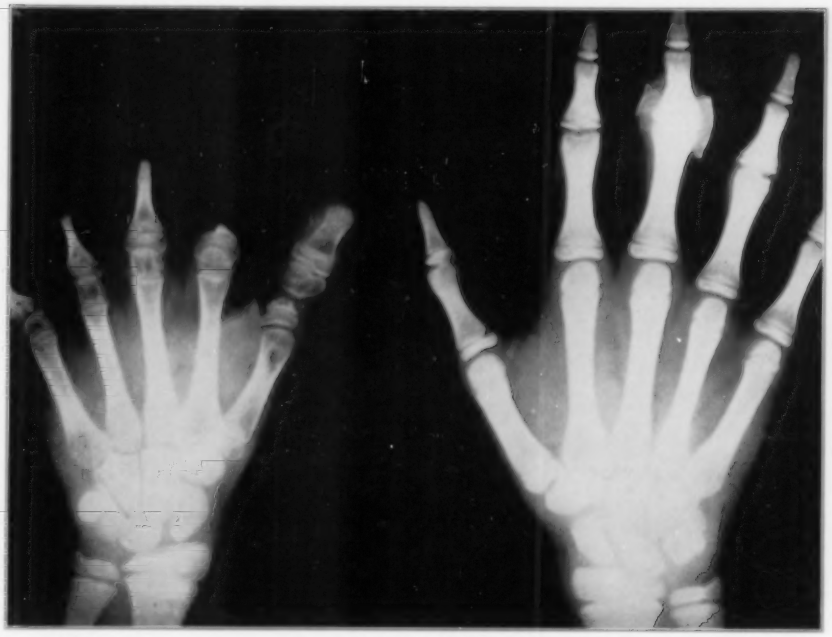


FIG. 9-C

Fig. 9-C: Roentgenographic appearance of the transferred digit about six months after the transfer was done.

Fig. 9-D: Photograph showing the feet two years after operation. There is no foot disability. She walks, runs, and plays hockey in ordinary shoes. There are no tender points or callosities.

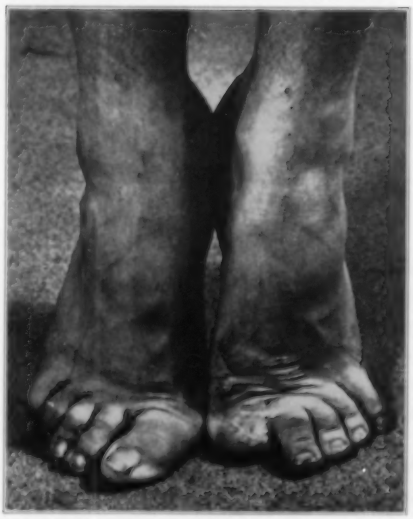


FIG. 9-D

anteriorly to create a dorsal defect proximal to the digit or digits to be restored, and this area is approximately the area of the dorsal flap on the foot. The hand, after such tendon attachment as is to be described later, is then sutured under the dorsal flap on the foot. Fixation, with the knee and the hip in acute flexion, is by zinc-oxide strapping. Care must be taken to avoid weight-bearing on the ischial tuberosity. One of my patients (a child) acquired a temporary sciatic palsy as a result of this.

3. *Attachment of Tendons*

The extensor tendons of the toes are attached to the distal cut tendons of the missing fingers either on the back of the hand or in the forearm, whichever is more appropriate. It is possible to do a flexor-tendon transfer at the same time. Thus the flexor hallucis longus may be cut behind the ankle and threaded through the metatarsophalangeal joint and through the thenar eminence and wrist. It can then be attached to a forearm flexor motor unit above the wrist. If other toes have been used, the long flexors can be divided in the sole of the foot (by Henry's medial approach) just distal to the attachment of the accessorius and then threaded through the metatarsophalangeal joints.

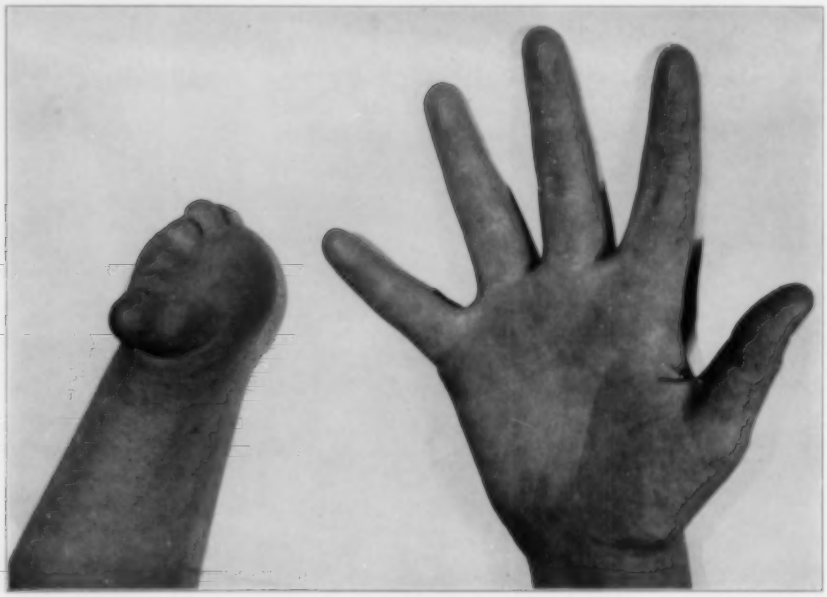


FIG. 10-A

Case 2. Treatment of complete adactylia by five-toe transfer. The hand, distal to the mid-palm, is represented by little vestigial buttons for digits.

It would be perfectly practicable in cases of trauma to do digital-nerve attachments, but I have not done this. In one patient, I carried away the third metatarsal in the foot flap together with the long extensor and the long flexors of the third toe. Division through the base of the third metatarsal led directly down to the long flexor tendons of this toe.

4. *Detachment of the Toes from the Foot*

It has been my custom to divide the digital vascular pedicles on each side separately, doing the first side a fortnight after the attachment of the flap and the second side a fortnight later, then amputating the toe through the metatarsophalangeal joint after a further two weeks. This makes a total period of attachment of six weeks. It might well prove possible to shorten this period, but I have hesitated to do so. One modification in technique which might enable this to be done safely would be to divide the one digital vascular pedicle at the time of the delaying of the dorsal flap on the foot.

At the amputation, when the toes are carried away with the hand, there is left a raw area on the distal portion of the foot which I cover with a split-thickness skin graft. On the volar aspect of the hand at the junction of the transferred digits and the palm is another raw area. I have covered this sometimes with a split-thickness skin graft; but for three patients I used a belly-arm flap because it is through this raw area that the flexor tendons must go, whether they are the flexor tendons of the toe carried away at the time of the transfer or are later flexor-tendon grafts. A repair by belly-arm flap of this raw area is to the advantage of the mobility of the tendon.

5. *Later Remodeling*

Remodeling may include a thinning of a big toe or the deepening of the webs between a big toe transferred as a thumb and the other digits. It can also include tendolyses, tendon grafts, and purely plastic revision to improve appearance.

FIG. 10-B

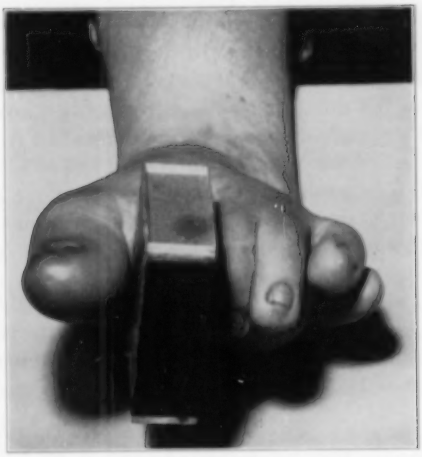


FIG. 10-C

Fig. 10-B: Photograph showing the attachment of the hand to the foot under a dorsal flap. This was maintained for six weeks. The dorsum of the foot was repaired by a dermatome graft.

Fig. 10-C: Simple gripping was provided by deepening the web between the thumb (big toe) and first digit and by a tendon graft from the forearm flexors around the pisiform bone to the thumb to provide opposition.

Fig. 10-D: The patient now feeds himself and is able to dress himself without help. He can also ride a bicycle securely and safely. He wears an ordinary boot and has no disability in the foot. Indeed, he plays football.

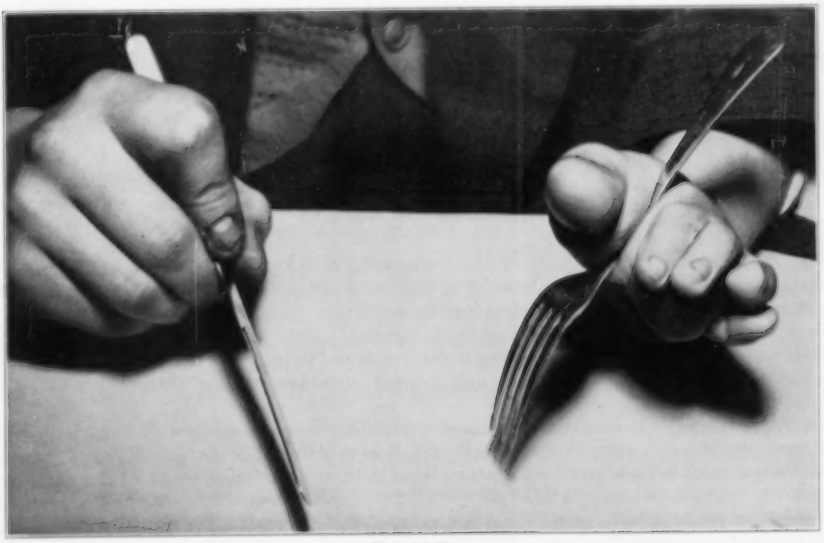


FIG. 10-D

RESULTS

I have transferred fifteen digits in six patients, and I have lost half a digit in one three-digit transfer. This loss was due to my faulty fixation of the hand to the foot and was not due to any inherent defect in the dorsal-flap method of transfer. I know of two other single-digit pedocarpal dorsal-flap transfers done in England in the last ten years. The first was done by Sir Harold Gillies and the second was done by Mr. James Cuthbert of Johannesburg. These were both done at the Basingstoke Plastic Centre and were completely successful, both from the point of view of survival and of adding significant function to the injured hand.

CONCLUSIONS

The transfer of one or more toes to the hand by the dorsal-flap method is entirely practicable and safe, and need cause no foot disability. A toe so transferred to the hand can add considerably to the function of an injured or deformed hand.

REFERENCES

BUNNELL, STERLING: Surgery of the Hand. Ed. 2, p. 538. Philadelphia, J. B. Lippincott Company, 1949.

NICOLADONI, C.: Daumenplastik und organischer Ersatz der Fingerspitze (Anticheiroplastik und Daktyloplastik). Arch. f. Klin. Chir., **61**: 606–614, 1900.

DISCUSSION

THE USE OF RADIO-ACTIVE PHOSPHORUS (P^{32}) TO DETERMINE THE VIABILITY OF THE HEAD OF THE FEMUR

(Continued from page 269)

DR. BOYD (closing): Dr. Fahey's excellent discussion is appreciated. He asks why we feel that the trochanter-to-head ratio of radio-activity is an expression of the degree of viability rather than of the blood supply of the femoral head. We believe that the viability of the head of the femur is dependent upon the blood supply. However, the trochanter-to-head ratio at any given instant is not a direct evaluation of the blood supply, but it is a result of the four factors mentioned in the paper. We think that these factors are in turn dependent upon the blood supply and, therefore, that the amount of P^{32} in the bone is an index of its viability.

Dr. Fahey has made an excellent suggestion in regard to making end-window counts on cross sections of human femoral heads in order to determine the distribution of the P^{32} in the bone. If any of you are removing femoral heads in fresh fractures and are replacing them with prostheses, we would appreciate receiving the heads. We shall be happy to make the end-window counts. The patient should be given two microcuries of P^{32} per pound of body weight about two hours before the removal of the head. The head should be clearly marked for orientation.

COMPARISON OF CONGENITAL DEFECTS INDUCED IN DEVELOPING CHICKENS BY CERTAIN TERATOGENIC AGENTS WITH THOSE CAUSED BY INSULIN *†

BY P. K. DURAISWAMI, PH.D., M.S., M.CH.ORTH., F.R.C.S., BALTIMORE, MARYLAND

From the Robert W. Johnson Orthopaedic Research Laboratory, the Children's Hospital School, Baltimore

In a review of the work on experimental teratogenesis in a previous article [12] the author had referred to the congenital abnormalities induced by various workers with sulfonamide compounds [2, 3], thallium salts [28], cortisone [29, 31], 3-acetylpyridine [1], and lead salts [5, 7, 18, 30, 36, 41]. As mentioned in that article, these experiments have been repeated by the author for two reasons. First, roentgenographic and histological investigations similar to those made for insulin-induced congenital abnormalities had not been carried out for most of these congenital defects. The micromelia observed by some of these authors in the treated embryos could have been due to a generalized developmental disturbance of bone resembling osteogenesis imperfecta and not necessarily to achondroplasia, as they had assumed. Second, by repeating these experiments with appropriate roentgenographic and histological investigations, the author has had an opportunity to compare the developmental anomalies induced by the substances described with those caused by insulin. Furthermore, it was observed when the experiments with 3-acetylpyridine were repeated that this substance induced myodystrophy and not micromelia.

More recently, benzyl alcohol was found to possess teratogenic properties by the author [13] in the course of certain "control" experiments performed simultaneously with the injections of cortone acetate ** into the yolk sacs of chicken eggs. In cortone acetate a saline suspension of 11-dehydro-17-hydroxycorticosterone-21-acetate is preserved in 1.5 per cent. benzyl alcohol. One half of the control eggs were, therefore, injected with isotonic saline solution and the other half with varying doses of benzyl alcohol. Although benzyl alcohol did not show obvious teratogenic properties when injected in low concentrations, such as 1.5 per cent. (in saline) as in cortone acetate, meningocele and certain limb and beak defects resulted when 0.01 to 0.02 cubic centimeter of *undiluted* benzyl alcohol was injected during the first week of incubation. An account of the developmental anomalies, including angulation of the tibia, caused by benzyl alcohol injected into the eggs at various intervals after the beginning of their incubation has been published elsewhere [13].

For purposes of comparison it is proposed to consider here only those defects observed after the injections of suitable doses of insulin, soluseptasine (a water-soluble sulfonamide compound), thallium nitrate, benzyl alcohol, lead nitrate, 3-acetylpyridine, and cortone acetate into the yolk sacs of chicken eggs ninety-six hours after the beginning of their incubation. In this way it is hoped that the teratogenic specificity of each substance will be satisfactorily demonstrated. In order to provide additional evidence, certain experiments which involved the injection of cortone acetate together with each of the other substances ninety-six hours after the beginning of incubation of the eggs have been conducted [11, 12] and some of these results will be presented in this paper.

MATERIAL AND METHODS

The present series of experiments were conducted with eggs from New Hampshire red chickens which were known to be free from genetic abnormalities and from nutritional

* Read at the Annual Meeting of The American Orthopaedic Association, Hot Springs, Virginia, July 2, 1953.

† These investigations were supported by the Thomas H. Bowles Research Fund.

** Supplied by Merck and Co., Inc.

FIG. 1-A

FIG. 1-B

Fig. 1-A: Roentgenogram of a normal twenty-day embryo. (Reproduced by permission from *Bulletin of the Johns Hopkins Hospital*, **95:** 63, 1954.)

Fig. 1-B: Roentgenogram of a twenty-day embryo treated with five units of insulin on the fourth day of incubation, showing generalized developmental disturbance of bone resembling the prenatal type of osteogenesis imperfecta, with defective ossification. The associated deformities of the long bones of the limbs are obviously responsible for the micromelia. Such embryos invariably fail to hatch from their shells. Note the arched upper beak ("parrot beak").

deficiencies. The methods employed for the incubation of the eggs, injection of various teratogenic substances, treatment of control eggs, and for conducting histological and roentgenographic investigations on chick embryos were, for all practical purposes, the same as those described previously [10, 12]. It is important to note that only one injection of each teratogenic substance was made into the yolk sac of the egg ninety-six hours after the beginning of incubation. In those experiments in which two substances had to be injected into the same egg, the same rule was followed and the two substances were injected into two different sites in the yolk sac, one injection immediately following the other, and no additional injections were made into the same egg.

OBSERVATIONS

As mentioned, only those developmental anomalies induced by injections of appropriate doses of insulin, soluseptasine, thallium nitrate, lead nitrate, 3-acetylpyridine, and cortone acetate into the eggs ninety-six hours after the beginning of their incubation will be considered. For purposes of comparison only those embryos which survived for at least a week after injection have been taken into consideration. Since the severity of the defects precluded hatching of the chicks treated with certain teratogenic substances, for the sake of uniformity the chick embryos were removed from their shells at specified periods before hatching.

The developmental anomalies induced by the various teratogenic substances have been illustrated in Figures 1-A to 9.

FIG. 1-C

FIG. 1-D

Fig. 1-C: Roentgenogram of a twenty-day embryo treated with 0.1 cubic centimeter of 10 per cent. solution of soluseptasine on the fourth day of incubation. Generalized developmental disturbance of bone, resembling the prenatal type of osteogenesis imperfecta, with defective ossification is evident. The associated deformities of the long bones of the limbs are obviously responsible for the micromelia. Note the parrot beak.

Fig. 1-D: Roentgenogram of a twenty-day embryo treated with one milligram of thallium nitrate on the fourth day of incubation. Generalized developmental disturbance of bone, resembling the prenatal type of osteogenesis imperfecta, with defective ossification is evident. The associated deformities of the long bones of the limbs are obviously responsible for the micromelia. Note the absence of the lower beak.

Insulin

The defects caused by injections of different doses of insulin ninety-six hours after the beginning of incubation have been described in detail previously [10, 11, 12]. In this paper the angulation deformities of the tibiae and the associated beak and other defects induced by insulin will be compared with those produced by soluseptasine and thallium nitrate. Three units of insulin were injected into the eggs ninety-six hours after the beginning of their incubation and the embryos surviving the eleventh day of incubation were examined. Of 225 embryos scrutinized 107 (47.5 per cent.) showed angulations of one or both tibiae and twenty-eight (12.0 per cent.) showed beak defects, including "parrot beak". The limb defects are illustrated in Figures 2-A and 2-C. The degeneration in the cartilaginous core of the tibia and the radial arrangement of the bone trabeculae at the site of angulation are evident in Figures 2-C and 2-D.

Soluseptasine

Following injection of 0.05 cubic centimeter of a 10 per cent. aqueous solution of soluseptasine into the eggs ninety-six hours after the beginning of incubation, the embryos which survived the eleventh day of incubation were examined. Of 229 embryos scrutinized, 132 (57.6 per cent.) showed angulations of one or both tibiae and sixty-nine (30.1 per cent.) showed typical parrot-beak defects. The radial arrangement of bone trabeculae at the apex of the angulation in the tibia is shown in Figure 2-F. In view of this arrangement of the trabeculae almost at right angles to the normal line of weight-bearing in the tibia,

it can be readily seen why even normal weight-bearing may result in a pathological fracture and later in pseudarthrosis. Moreover, this radial disposition of the trabeculae may well be responsible for the obliteration of the marrow cavity which is considered to be a typical feature of the "prepseudarthrosis type of bowing" [37, 38].

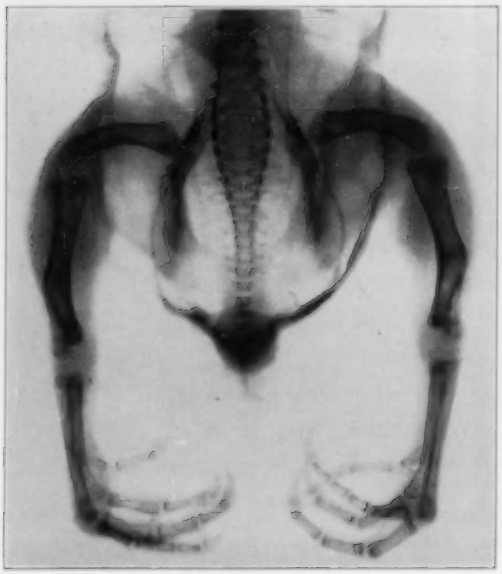


FIG. 2-A

It is interesting to note that the angulations of the tibia produced in chickens by insulin, soluseptasine, thallium nitrate, and benzyl alcohol present most of the essential features described by McFarland and by Badgley and his associates for congenital kyphoscoliotic tibia in man, although the etiology of the latter is not known. The features common to both the clinical and the experimental conditions are the following:

Fig. 2-A: Roentgenogram of a week-old chicken with angulation of both tibiae. Three units of insulin had been injected into the egg on the fourth day.

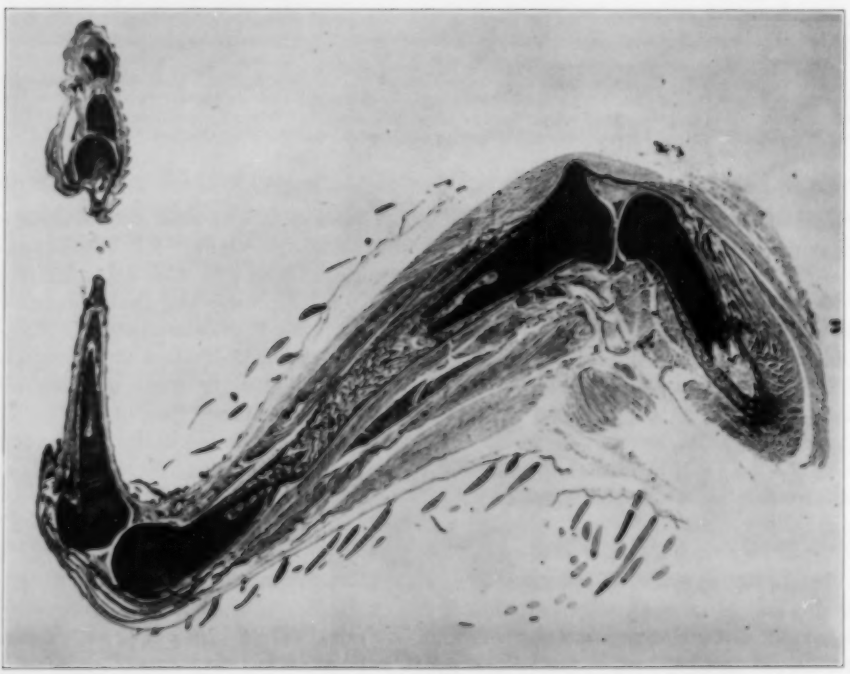


FIG. 2-B

Sagittal section of the tibia (× 10.5, toluidine-blue stain) of a normal twelve-day embryo. The cartilaginous core of the tibia at the ends of the bone has been stained deep lilac by the metachromatic stain. Ossification begins in the middle of the shaft and spreads toward the periphery, while the marrow cavity forms by absorption of the cartilaginous core. (Reproduced by permission of E. and S. Livingstone Ltd. from *The Journal of Bone and Joint Surgery*, **34-B**: 671, Nov. 1952.)

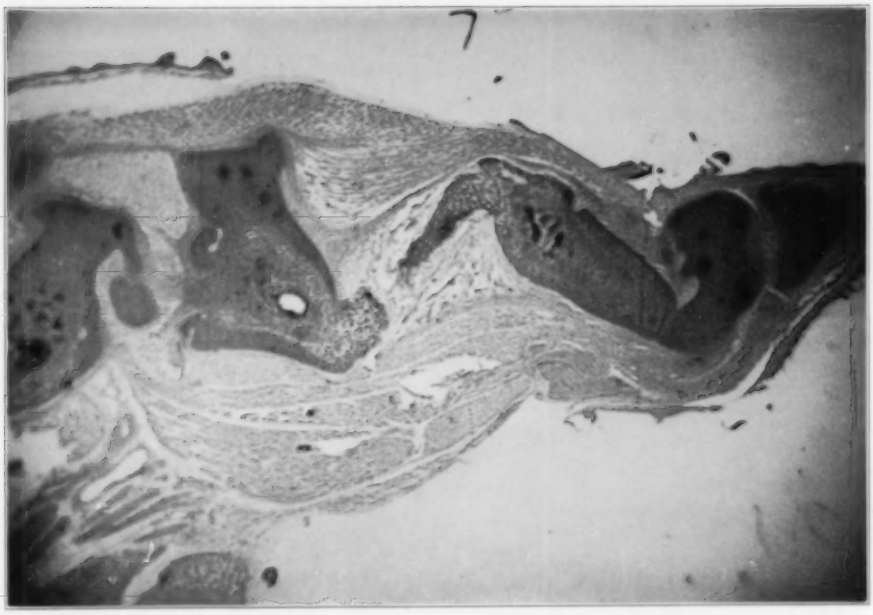


FIG. 2-C

Sagittal section of the tibia (× 21) of a twenty-day embryo treated with insulin on the fourth day of incubation. Note the angulation deformities of the tibia and the severe degree of degeneration in its cartilaginous core. Compare with Fig. 2-B. (Reproduced by permission of E. and S. Livingstone Ltd. from *The Journal of Bone and Joint Surgery*, **34-B**: 671, Nov. 1952.)

1. The site of the lesion is the distal portion of the middle third of the tibia.
2. The anterior type of angulation is much more common than the posterior.
3. A dense bone mass is found on the concave side of the tibia.
4. There is a predisposition to fracture and pseudarthrosis.
5. At the site of the angulation the bone trabeculae are arranged radially from the apex and do not, therefore, lie in the same longitudinal axis as the shaft of the tibia (Fig. 2-F).
6. Cystic changes are evident in the shaft of the tibia.

Thallium Nitrate

The embryos which survived the eleventh day of incubation after injections of 0.05 cubic centimeter of 2 per cent. aqueous solution of thallium nitrate into the eggs ninety-six hours after the beginning of incubation were examined. Of 198 embryos scrutinized, 176 (89.9 per cent.) showed angulations of one or both tibiae and 164 embryos (82.9 per cent.) had diminutive or absent lower beaks with highly arched upper beaks.

The island of cartilage at the site of angulation of the tibia is evident in Figure 2-G. This gives rise to a cystic appearance in the roentgenogram. The etiology of the cystic changes in the shaft of the tibia associated with pseudarthrosis in children is not known.

Lead Nitrate

The embryos which survived the eleventh day of incubation following injections of 0.05 cubic centimeter of 1.6 per cent. aqueous solution of lead nitrate into the eggs ninety-six hours after the beginning of incubation were examined. Of 232 embryos examined, 171 (74.0 per cent.) showed meningocele, cranioschisis, and hydrocephalus, as well as associated paralytic deformities of the limbs and feet.

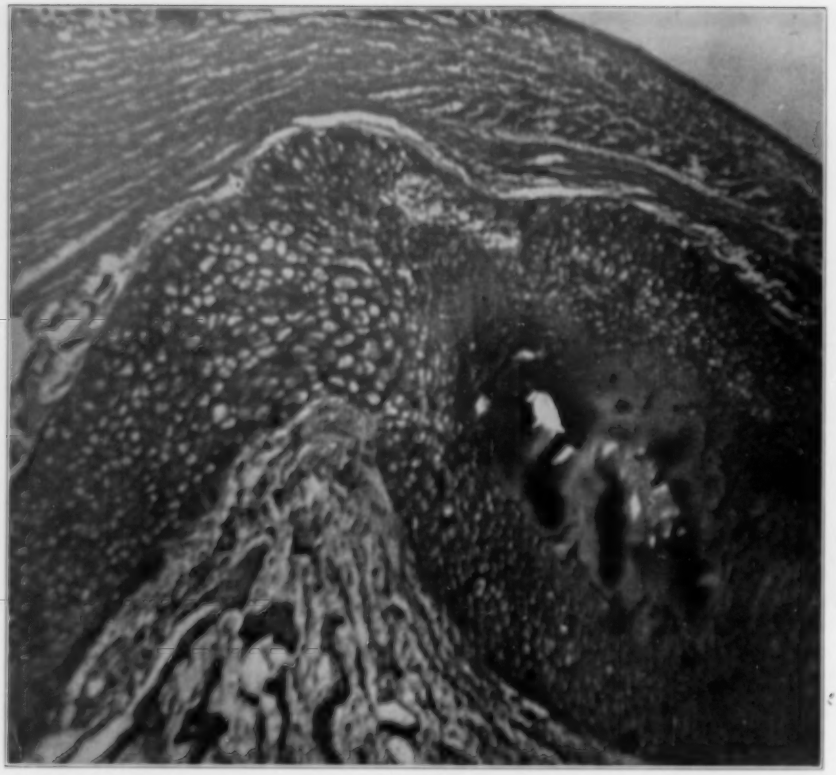


FIG. 2-D

FIG. 2-E

(*See page 283*)

Fig. 2-D: Photomicrograph (× 100) of a section taken from the site of angulation of the tibia of the insulin-treated embryo shown in Fig. 2-C. Note the radial arrangement of the bone trabeculae from the apex and the severe degree of degeneration in the cartilaginous core.

Fig. 2-E: Photomicrograph (× 85) of a section taken from the site of angulation of the tibia of a twelve-day soluseptasine-treated embryo.

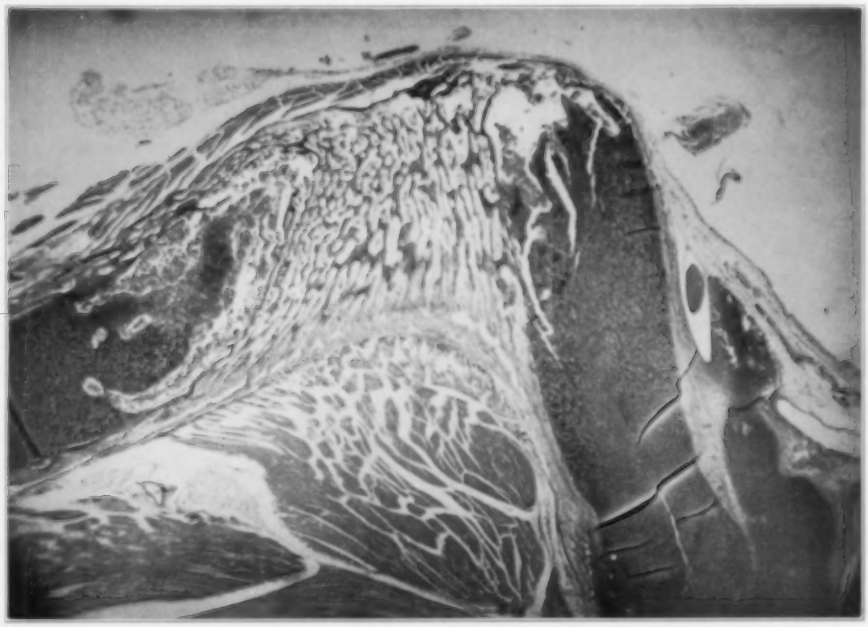


FIG. 2-F

Photomicrograph (× 85) of a section taken from the site of angulation of the tibia of a twenty-day soluseptasine-treated embryo. Note the radial disposition of bone trabeculae; this is responsible for the obliteration of the marrow cavity.

3-Acetylpyridine

The embryos surviving the eleventh day after the beginning of incubation were examined. Of 268 embryos examined, 142 (52.9 per cent.) showed varying degrees of myodystrophy (Figs. 3-A and 3-B). As illustrated in Figure 3-A, the limbs are normal in their linear measurements but are definitely thinner than those of the controls because of myodystrophy, as is evident from the photomicrograph (Fig. 3-B). Myodystrophy of the spinal muscles has given rise to scoliosis. The associated beak defect, as a rule, is shortening of the upper beak (Fig. 3-A).

Cortone Acetate

In all, 209 embryos which survived the eleventh day of incubation following injections of two milligrams of cortone acetate into the eggs ninety-six hours after the beginning of incubation were examined. The outstanding teratogenic effects observed were the following (it should be noted that two or more defects were present in some embryos):

	No. of Embryos
Marked inhibition of general growth	74
Ectopia viscerum, varying from mild exomphalos to massive evisceration of gut, liver, and heart	152
Inhibition of extra-embryonic membrane formation and production of amniotic bands and blebs	62
General oedema of body and absence of feather formation	25

TABLE I

TERATOGENIC EFFECTS OF COMBINATIONS OF SUBSTANCES

Substances Combined and Their Doses*	No. of Embryos Examined	Embryos with Two Types of Defects (*No.*)	(*Per cent.*)	Types of Defects
Cortone acetate (2 milligrams) Insulin (3 units)	144	106	73.6	Ectopia viscerum. Limb defects, parrot beak.
Cortone acetate (2 milligrams) Soluseptasine (0.05 cubic centimeter)	146	92	63.0	Ectopia viscerum. Limb defects, parrot beak.
Cortone acetate (2 milligrams) Thallium nitrate (1 milligram)	156	137	87.8	Ectopia viscerum. Limb defects, very short lower beak.
Cortone acetate (2 milligrams) Lead nitrate (0.8 milligram)	147	114	77.5	Ectopia viscerum. Meningocele.
Cortone acetate (2 milligrams) 3-acetylpyridine (0.5 milligram)	153	86	56.2	Ectopia viscerum. Thin limbs and scoliosis due to myodystrophy.

* In each combination of substances, one substance was injected immediately after the other.

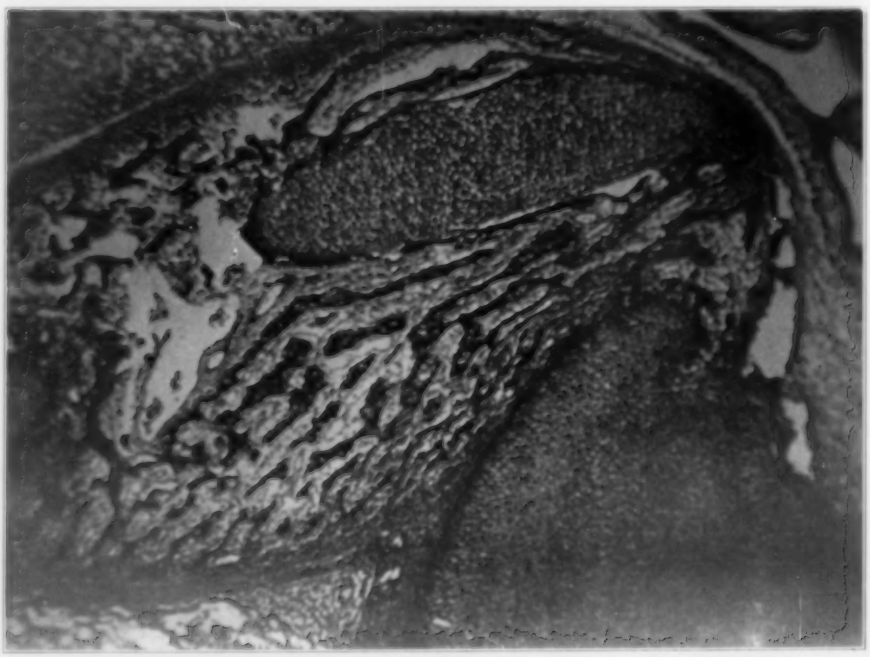


FIG. 2-G

Photomicrograph (× 85) of a section taken from the site of angulation of the tibia of a twelve-day thallium-treated embryo. Note the island of cartilage, which may give rise to a cystic appearance in the roentgenogram.

Injection of Two Substances

Although injections of various combinations of the teratogenic substances described have been successfully tried, for the purpose of this paper it is proposed to confine our attention only to those defects induced by the combination of cortone acetate with each of the following substances: insulin, soluseptasine, thallium nitrate, lead nitrate, and 3-acetylpyridine. As mentioned, the two substances in each combination were injected in two different sites in the yolk sac ninety-six hours after the beginning of incubation. Table I shows the incidence of the specific defects produced by the appropriate combinations among the treated embryos which survived the eleventh day of incubation. The defects have been illustrated in Figures 4 to 9.

From the results in Table I it would appear that each teratogenic substance induces its specific defect or syndrome, whether it is injected by it-

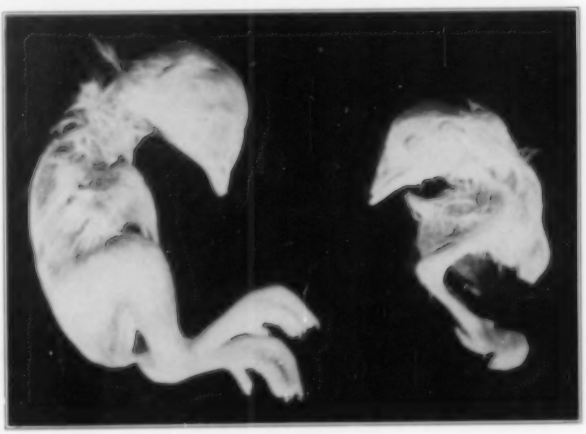


Fig. 3-A: Twenty-day embryo showing scoliosis and thin limbs due to myodystrophy induced with 0.5 milligram of 3-acetylpyridine injected into the yolk sac on the fourth day of incubation. Note the short upper beak. A normal twenty-day embryo is shown on the left.

FIG. 3-A

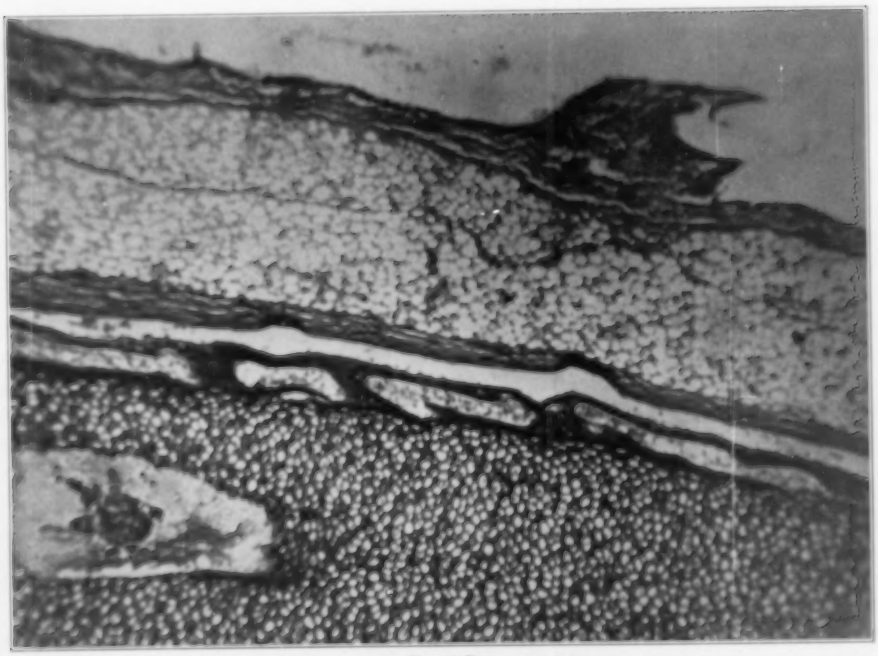


FIG. 3-B

Photomicrograph (× 85) of a section taken from the tibia of the embryo treated with 3-acetylpyridine shown in Fig. 3-A. Note that fibrofatty tissue has replaced the layer of muscle which should normally be seen between the periosteum of the tibia and subcutaneous tissue.

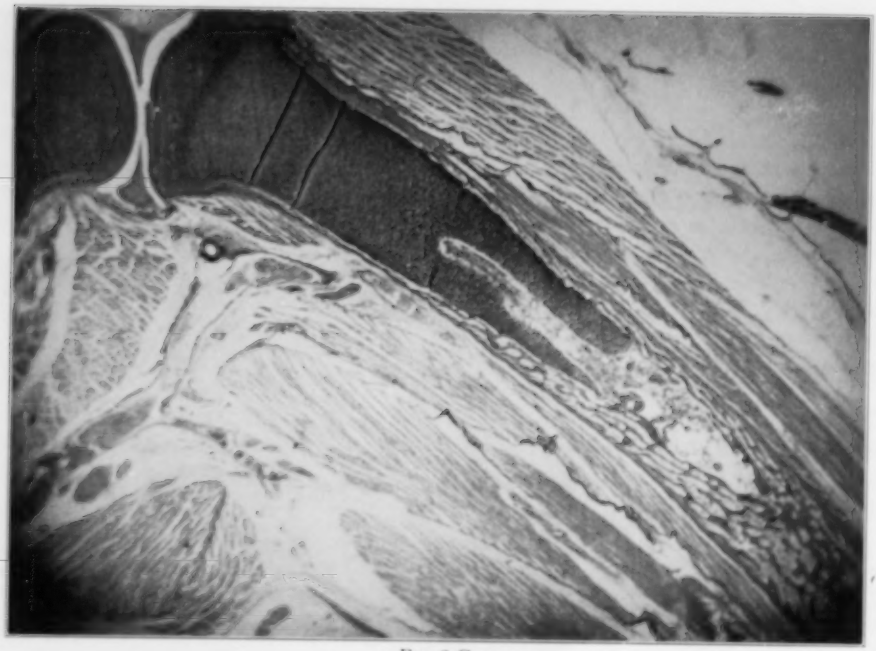


FIG. 3-C

Sagittal section (× 42) of the proximal half of the tibia of the normal embryo shown in Fig. 3-A.

self or together with another substance, provided the actions of the two are not antagonistic. In other words, each of these substances possesses what may be termed teratogenic specificity.

Controls

In every group of experiments an adequate number of control eggs were injected with saline and incubated in the same incubators as the eggs treated with various teratogenic substances. In all, 605 control embryos which survived the eleventh day of incubation were examined, and fourteen of these (2.3 per cent.) showed defects of one type or another. However, it is pertinent to point out that none of these defects was seen consistently among the controls.

DISCUSSION

From the foregoing observations it seems clear that teratogenic substances such as insulin, cortone acetate, 3-acetylpyridine, and lead nitrate can induce different types of developmental malformations, even though the technique, the time of injection, the method of incubation, and other relevant factors are, for all practical purposes, the same. On the other hand, angulation deformities of the tibia can be caused by substances with different chemical compositions, such as insulin, sulfonamide compounds, thallium nitrate, and benzyl alcohol. Does it necessarily follow that insulin, sulfonamide, thallium nitrate, and benzyl alcohol act in an "unspecific" manner in producing angulation of the tibia? The experimental evidence at our disposal points to the contrary.

In the case of insulin, for example, hypoglycaemia may play a part in the causation of the appropriate deformity [10, 12, 48], whereas sulfonamide seems to induce the defect without lowering the blood sugar of the treated embryos [50]. However, nicotinamide can prevent to a remarkable extent the defects induced by both insulin and sulfonam-

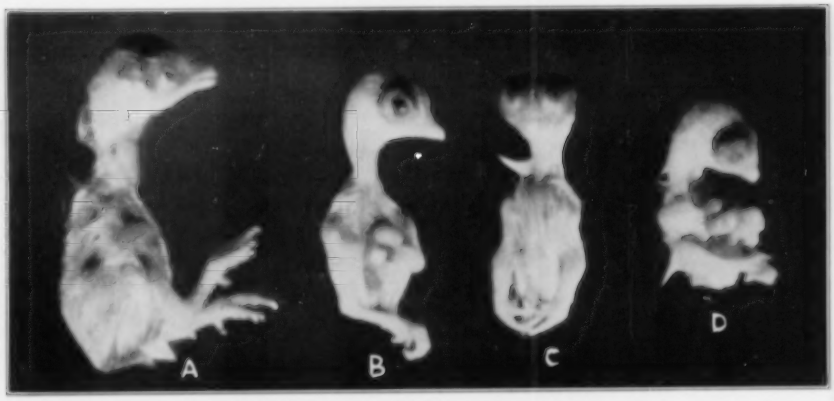


FIG. 4

All embryos were sixteen days old. *A*, normal control; *B*, embryo showing ectopia viscerum and clawing of toes induced by two milligrams of cortone acetate injected into the yolk sac on the fourth day of incubation; *C*, embryo showing limb deformities induced by two units of insulin injected into the yolk sac on the fourth day of incubation; *D*, embryo showing both ectopia viscerum and limb deformities caused, respectively, by two milligrams of cortone acetate and two units of insulin substance injected into two different sites of the yolk sac on the fourth day of incubation, one immediately following the other. Teratogenic specificity is illustrated by this and other corresponding embryos shown in Figs. 5 to 9.

ide[10, 12, 32, 50]. It has been observed[28] that nicotinamide has no such protective action in the case of thallium-induced defects. Further investigations with a view to studying, as far as possible, the mechanisms which may be involved in the causation of developmental anomalies by these various teratogenic substances are in progress.

For many years, eminent teratologists, including Stockard, whose fascinating experiments in teratogeny are well known, held the view that congenital malformations result from what was termed "unspecific retardation or arrest of embryonic development". Undoubtedly, retardation or arrest of development of the embryo can give rise

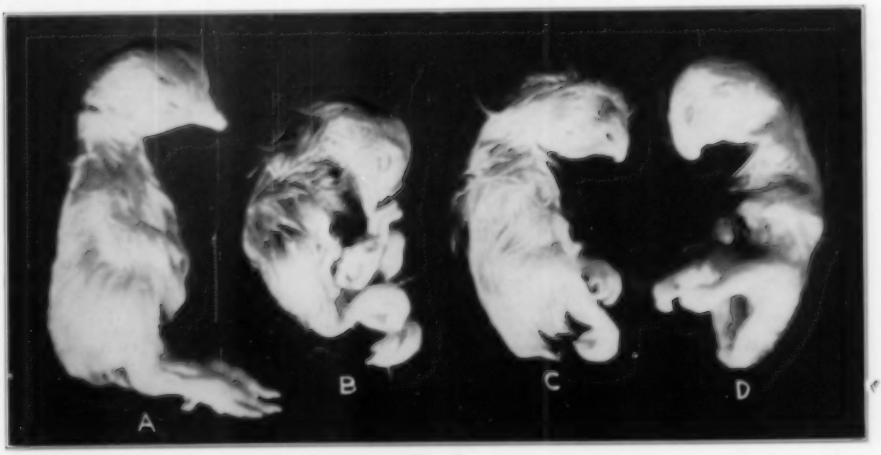


FIG. 5

All embryos were eighteen days old. *A*, normal control; *B*, embryo showing ectopia viscerum and clawing of toes induced by two milligrams of cortone acetate on the fourth day of incubation; *C*, embryo showing limb deformities and parrot beak induced by 0.05 cubic centimeter of a 10 per cent. solution of soluseptasine injected into the yolk sac on the fourth day of incubation; *D*, embryo showing ectopia viscerum and limb deformities associated with parrot beak, caused, respectively, by two milligrams of cortone acetate and 0.05 cubic centimeter of soluseptasine, the substances having been injected into two different sites of the yolk sac on the fourth day of incubation, one immediately following the other.

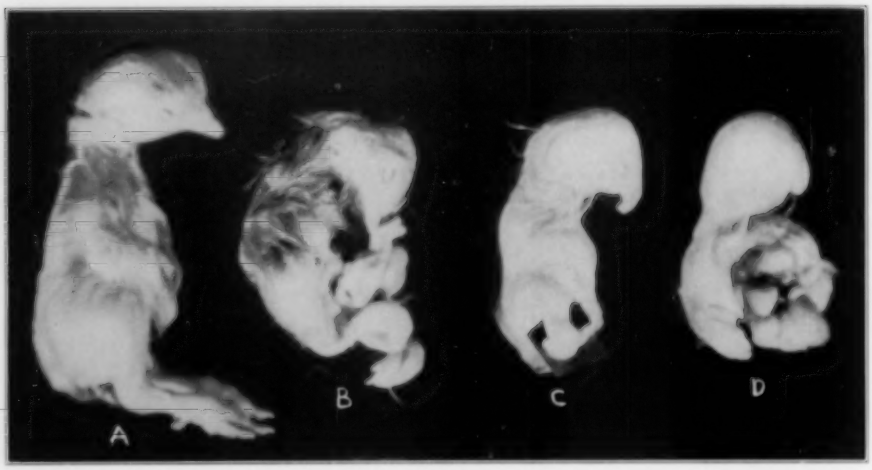


FIG. 6

All embryos were eighteen days old. *A*, normal control; *B*, embryo showing ectopia viscerum and clawing of toes induced by two milligrams of cortone acetate injected into the yolk sac on the fourth day of incubation; *C*, embryo showing short deformed limbs and arched upper beak, with absence of lower beak, induced by one milligram of thallium nitrate injected into the yolk sac on the fourth day of incubation; *D*, embryo showing both ectopia viscerum and limb deformities associated with typical beak defects caused respectively by two milligrams of cortone acetate and one milligram of thallium nitrate, the substances having been injected into two different sites of the yolk sac on the fourth day of incubation, one immediately following the other.

to certain types of congenital anomalies, but the converse is not necessarily true. Developmental malformations may also result from degeneration in tissues or organs which had developed normally up to a certain stage, as has been demonstrated in the case of insulin-induced deformities (Fig. 2-D)[10, 12], rubella-induced lenticular lesions[43], and cortisone-induced cleft palate[15]. As in the case of insulin, the degenerative changes may well result from derangements in specific metabolic, biochemical, enzymatic, or other processes,

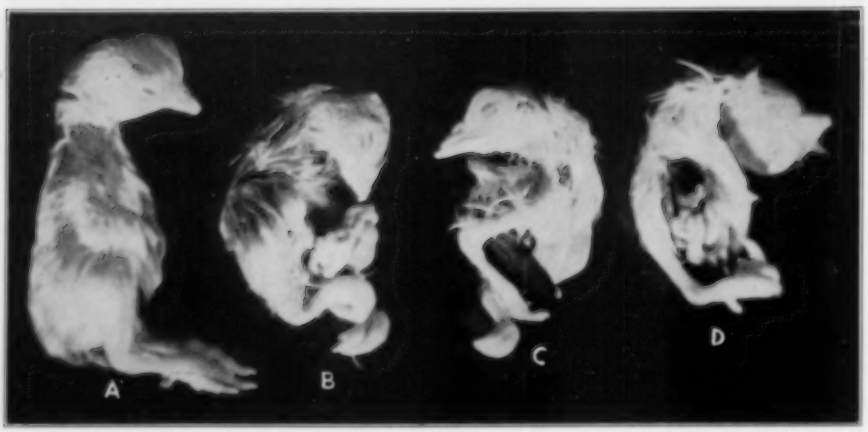


FIG. 7

All embryos were eighteen days old. *A*, normal control; *B*, embryo showing ectopia viscerum and clawing of toes induced by two milligrams of cortone acetate injected into the yolk sac on the fourth day of incubation; *C*, embryo showing scoliosis and thin limbs due to myodystrophy induced by 0.5 milligram of 3-acetylpyridine injected into the yolk sac on the fourth day of incubation; *D*, embryo showing both ectopia viscerum and myodystrophy caused, respectively, by two milligrams of cortone acetate and 0.5 milligram of 3-acetylpyridine, the substances having been injected into two different sites of the yolk sac on the fourth day of incubation, one immediately following the other.

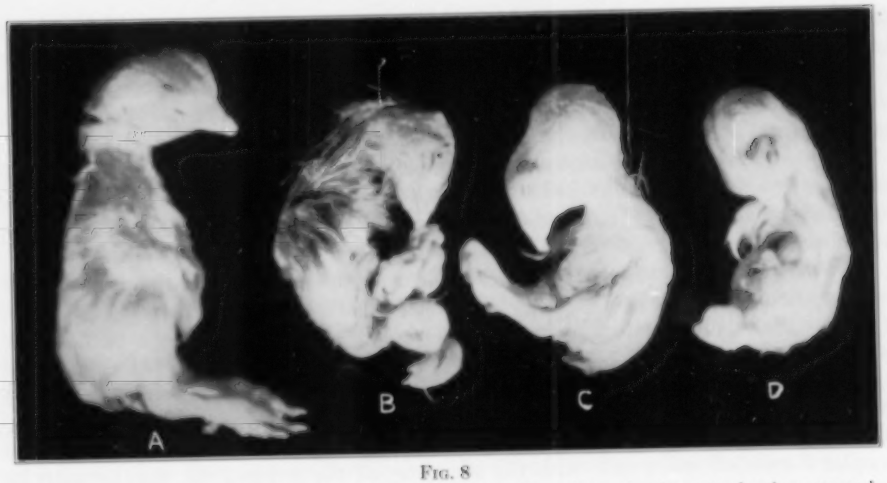


FIG. 8

All embryos were eighteen days old. *A*, normal control; *B*, embryo showing ectopia viscerum and clawing of the toes induced by two milligrams of cortone acetate injected into the yolk sac on the fourth day of incubation; *C*, embryo showing meningocele and paralytic clawing of toes induced by 0.8 milligram of lead nitrate injected into the yolk sac on the fourth day of incubation; and *D*, embryo showing both ectopia viscerum and meningocele caused, respectively, by two milligrams of cortone acetate and 0.8 milligram of lead nitrate, the substances having been injected into two different sites of the yolk sac on the fourth day of incubation, one immediately following the other.

caused by the respective teratogenic agents during phases critical for these processes.

Ancel and other workers [33, 50] have provided experimental evidence which indicates that the specific action of a teratogenic agent is responsible for determining the nature of the induced abnormality. As has been demonstrated, our own experimental observations lend support to this view of teratogenic specificity.

When we consider Stockard's hypothesis of "unspecific retardation or arrest of

FIG. 9

All embryos were eighteen days old. *A*, normal control; *B*, embryo showing very short deformed limbs, arched upper beak, and absence of lower beak induced by one milligram of thallium nitrate injected into the yolk sac on the fourth day of incubation; *C*, embryo showing meningocele and paralytic clawing of toes induced by 0.8 milligram of lead nitrate injected into the yolk sac on the fourth day of incubation; *D*, embryo showing very short limbs associated with typical beak defects and meningocele caused, respectively, by one milligram of thallium nitrate and 0.8 milligram of lead nitrate, the substances having been injected into two different sites of the yolk sac on the fourth day of incubation, one immediately following the other.

development", we must remember particularly two facts which he summarized in the following statements:

"The present extremely crude state of our knowledge of the chemistry of development will permit of no more satisfactory statements of the principles underlying differences in developmental rate than those which have been attempted above."

"Although there is a definitely normal rate of development for a given egg, this rate is frequently subject to wide variations, usually as a result of variations in the surrounding conditions. The two chief, or most frequent, modifying causes are a change in oxygen supply or a change in temperature."

In the light of important advances in many branches of science during the past few decades, various workers [10, 12, 20, 21, 25, 33, 40, 50] have been attempting to explain the causation of developmental abnormalities induced by anoxia, alterations of environmental temperatures, and many chemical and other teratogenic factors on the basis of well understood metabolic, biochemical, and histological processes. Herrmann [20, 21], who has demonstrated that certain amino-acid analogues act as teratogenic agents in developing chick embryos, says [21]: "Most of the experimental teratogenic agents, from ordinary lithium ions to highly complex insulin, interfere only with the chemistry of the cell and not directly with its morphological characteristics."

The question has been raised by some critics whether experimental observations made in lower animals can have any practical application in so far as the etiology and pathology of human congenital defects are concerned. It must be stated that hasty and unwarranted attempts to apply the results obtained from animal experiments to congenital anomalies in man without adequate scientific basis will only damage the cause these attempts are supposed to serve. At the same time it is well to remember Warkany's warning that "it is equally dangerous to make sweeping negative statements in this field".

Next, we must consider some of the difficulties inherent in an investigation of the etiology and pathology of developmental anomalies in man and explore the possible ways of overcoming them. The development of mammals, including man, is concealed in the maternal uterus and is, therefore, a difficult field for investigation. It is unfortunate that we do not at the present time make the best use of the most valuable source of information on the subject,—that is, the embryos and foetuses aborted or miscarried. In Hertig's series, thirteen of thirty-six embryos under seventeen days, recovered from 185 surgically removed uteri, were abnormal. With regard to recognizable abortions, developmental malformations of various types and degrees were noted in approximately 48 per cent. of the embryos and foetuses examined [22, 24]. Corner [9] believed that both genetic and environmental factors are responsible for malformations and mortality of embryos. The greatest practical difficulty in the study of spontaneously aborted embryos is that they show postmortem degenerative changes before accurate histological methods can be applied. As has been emphasized [12], all pathological examinations of such specimens should be carried out with the least possible delay after abortion, spontaneous or therapeutic. Furthermore, routine examination of all surgically removed uteri, according to the methods followed by Hertig and his associates and by others, may enable us to obtain much valuable information. Those interested in experimental teratogenesis cannot fail to be impressed with the incidence of gross malformations in embryos which die at varying intervals after appropriate treatment with teratogenic agents. Often these embryos offer valuable clues to an understanding of the mechanism of action of the various teratogenic agents, as well as of the pathology of the malformations induced. They may also provide opportunities to compare the developmental malformations in human embryos. Every effort should, therefore, be employed to make use of the advances in different branches of science for filling this wide gap in our knowledge of foetal pathology. In this way, we may be able to provide satisfactory answers to the critics who doubt the practical application of experimental observations to congenital defects in man.

These difficulties seem minor when we consider the problem of studying the changes in the biochemical, metabolic, and other processes induced in man by abnormal genes and environmental teratogenic factors. In the present state of our knowledge we may have to rely, for the most part, on animal experiments. It is for this reason that every possible attempt should be made to explain the teratogenic mechanisms involved in experimentally induced developmental abnormalities in terms of disturbances to specific metabolic, biochemical, and other processes; we cannot rest content with the earlier hypothesis of unspecific retardation or arrest of embryonic development. If we can definitely establish the causal relationship between such disturbances and the experimentally induced anomalies, we will have found a way of investigating whether analogous alterations in metabolic, biochemical, and other processes are responsible for congenital malformations in man also.

Modern embryology conceives of the embryo, including the human embryo[8], as many groups of cells, proliferating and differentiating under the direction of "organizers" which secrete specific chemical substances. The action of the genes is believed to be effected by the production of catalysts, which speed up chemical reactions, or of inhibitory substances. Thus, there may be hardly any difference, in so far as the effects on organizers are concerned, between the action of an abnormal gene and that of an environmental teratogenic factor. In fact, adverse environmental influences can give rise to developmental anomalies indistinguishable from those caused by faulty genes. At times, discussion of the etiology of developmental malformations has tended to become a controversy as to whether abnormal genes or environmental factors are concerned. Protagonists of both viewpoints often regard these factors as mutually exclusive. Most observers, however, agree that there is an interplay of genetic and environmental influences.

Haldane says: "Since geneticists commonly detect gene differences on the basis of morphological differences, this means, among other things, that the biochemistry of some critical steps in morphogenesis can be investigated. On the other hand, geneticists are likely to reach far greater precision in their work by using biochemical criteria whenever possible." In recent years geneticists, experimental teratologists, and biochemists[10, 12, 20, 33, 40, 44, 50] have been making investigations along the lines suggested by Haldane with the common aim of explaining the etiology of *both* types of congenital anomalies on a biochemical basis wherever possible. "The problem is a long-term one, especially since experimental results must be correlated with parallel clinical research; but in the end it may be, as Ingalls and his colleagues suggest, 'that intelligently conceived measures to protect the fragile embryo or the vulnerable foetus will ultimately be devised'." [14]

Having considered the importance of explaining the critical steps in morphogenesis induced by hereditary and environmental factors on a biochemical basis, let us turn our attention to the part played by abnormal metabolism caused by these factors in the etiology of congenital defects. "There is yet a more subtle way of injuring tissue; that is, by affecting its metabolism through suppression or overstimulation of the enzyme systems. In this category belong the anomalies produced . . . by vitamin deficiencies and those anomalies produced by hormonal influences such as injection of insulin." [40]

Experimental evidence has, in fact, been already presented[10, 12, 33, 48, 49] to show that insulin-induced abnormalities may result from a derangement of the carbohydrate metabolism. Growth and differentiation during embryonic development depend on a harmonious integration of a great variety of well regulated metabolic processes, each requiring its appropriate hormone and enzyme-substrate complexes, operating in a suitable environment. At any critical moment, the lack of a particular factor or group of factors, or the derangement of the metabolism or enzyme systems concerned, may lead to developmental anomalies. Gillman and his associates have induced in rats congenital abnormalities such as hydrocephalus, spina bifida, eye and ear defects, and malformations of the tail by subcutaneous injections of trypan blue in the mother during gestation. According to them

the dye does not enter the foetus. They believe that its teratogenic effect may well be secondary to a disturbance of the maternal metabolism and not to any direct toxic action on the foetus.

Some parallel observations have been made in man [47], but much remains to be investigated. Indirect evidence that a perverted metabolism in pregnant women can have serious consequences for the offspring was made available by the valuable contributions of some workers to the problems of endemic goiter [45] and pellagra [19, 24]. Gillman and his associates had, in fact, embarked on their experiments with trypan blue to obtain experimental evidence, if possible, in support of their hypothesis that the high incidence of abortions in African women, as well as the high mortality among African infants, is partly due to abnormal metabolism caused by chronic malnutrition. According to their hypothesis, "many syndromes are causally related to the combination of one or other of the plasma proteins with abnormal metabolites or particulate material derived from tissue breakdown in virus or bacterial infection, anoxia and chronic malnutrition or which gained entry abnormally into the circulation via the gut". They have planned a program to test the validity of this hypothesis and have begun with experiments on rats by injecting trypan blue.

It will be equally valuable if parallel studies are made in India and other countries in which gross malnutrition and unbalanced diets create similar problems. For example, those parts of India in which rice is almost the sole article of diet, the daily intake of protein is incredibly low, and gross deficiencies of vitamins and minerals exist would appear to be the ideal areas for carrying out studies on the effect of gross maternal nutritional deficiencies on the development of the offspring. Those who have full knowledge of the economic conditions and dietary habits of the rice-eating population in India will readily agree that nutritional deficiencies observed among the population are worse in many respects than those deliberately produced in experimental animals; this, of course, is also true of the dietary deficiencies in pregnant women. Although conceptions take place at a surprisingly high rate, the incidence of abortions, miscarriages, and neonatal and postnatal deaths is very high. It is not known what percentage of these embryos and foetuses show congenital anomalies. It is, therefore, reasonable to assume that statistics obtained from carefully conducted nutritional surveys will go a long way in providing a definite answer to the vexed question: What part does maternal nutritional deficiency during pregnancy play in the causation of congenital defects in man? Most of the dietary studies to the present have been made in Western countries among various social groups. The criticism has, therefore, been made that nutritional deficiencies observed in pregnant women in these surveys were not so severe as those produced in experimental animals. Research along the lines suggested may throw some light not only on the causative factors, but also on the preventive aspects of the problem.

It has been pointed out that the results of animal experiments are not necessarily valid when transferred to man [39]. According to Ingalls [26] "metabolic agents that can kill the conceptus may give rise to congenital malformation. In respect to oxygen lack, for example, some fragmentary clinical and epidemiologic facts are beginning to indicate that the findings made experimentally in mice may indeed apply to human beings." He has also cited a few clinical case reports in support of his hypothesis that "antioxidants or critical oxygen lack accompanying anesthesia during pregnancy may be teratogenic for the developing embryo and fetus". [26]

The role of other metabolic stresses resulting from diabetes, maternal iso-immunization, anaemia, toxaemia of pregnancy, and viral and other infections in the causation of developmental anomalies has been discussed in a previous article [12].

In conclusion, it may be reiterated that our aim should be to explain the mechanism of causation of human congenital abnormalities on the basis of well understood metabolic, biochemical, and other processes, whether they are induced by abnormal genes or by

environmental teratogenic factors, rather than by vague hypotheses of subcutaneous blebs or intra-uterine pressure. To further this aim we must leave no stone unturned in our attempts to explain the mechanisms of causation of experimentally induced developmental anomalies on a scientific basis. Villee, who studied the activity of various enzymes by incubating different tissues taken from twenty-six human foetuses obtained at therapeutic interruption of pregnancy in a variety of substrates labeled with radio-active carbon, says: "What we hope to do eventually is to be able to describe in biochemical terms the development of these different organs of the human being, much as the classical embryologist has described their anatomical differentiation". It is hoped that in the years to come scientifically planned and well co-ordinated research conducted by clinicians, epidemiologists, geneticists, and experimental embryologists will enable us to overcome the various difficulties which at present seem to stand in the way of applying the knowledge gained from animal experiments for a better understanding of the admittedly difficult problem of the etiology of human congenital anomalies.

REFERENCES

1. Ackermann, W. W., and Taylor, Alfred: Application of a Metabolic Inhibitor to the Developing Chick Embryo. Proc. Soc. Exper. Biol. and Med., **67**: 449–452, 1948.
2. Ancel, A.: La Chimiotératogénèse. Réalisation des Monstruosités par des Substances Chimiques chez les Vertébrés. Paris, G. Doin et Cie, 1950.
3. Ancel, A., et Lallemand, S.: Sur une malformation du bec et des membres obtenue chez l'embryon de poulet à l'aide des sulfamides. Comptes Rend. Soc. Biol., **136**: 225–256, 1942.
4. Badgley, C. E.; O'Connor, S. J.; and Kudner, D. J.: Congenital Kyphoscoliotic Tibia. J. Bone and Joint Surg., **34-A**: 349–371, Apr. 1952.
5. Bell, W. B.: An Address on the Influence of Lead on Normal and Abnormal Cell-Growth. Lancet, **1**: 267–276, 1924.
6. Butt, E. M.; Pearson, H. E.; and Simonsen, D. G.: Production of Meningoceles and Cranioschisis in Chick Embryos with Lead Nitrate. Proc. Soc. Exper. Biol. and Med., **79**: 247–249, 1952.
7. Catizone, Olga, and Gray, Peter: Experiments on Chemical Interference with the Early Morphogenesis of the Chick. II. The Effects of Lead on the Central Nervous System. J. Exper. Zool., **87**: 71–82, 1941.
8. Corner, G. W.: Ourselves Unborn. New Haven, Yale University Press, 1944.
9. Corner, G. W.: Discussion of Warkany's presentation [16].
10. Duraiswami, P. K.: Insulin-Induced Skeletal Abnormalities in Developing Chickens. British Med. J., **2**: 384–390, 1950.
11. Duraiswami, P. K.: Experimental Induction of Congenital Defects. Bull. Johns Hopkins Hosp., **10**: 447–450, 1952.
12. Duraiswami, P. K.: Experimental Causation of Congenital Skeletal Defects and Its Significance in Orthopaedic Surgery. J. Bone and Joint Surg., **34-B**: 646–698, Nov. 1952.
13. Duraiswami, P. K.: Experimental Teratogenesis with Benzyl Alcohol. Preliminary Report. Bull. Johns Hopkins Hosp., **95**: 57–67, 1954.
14. Editorial: Experimental Teratogenesis. Lancet, **1**: 177, 1954.
15. Fraser, F. C., and Fainstat, T. D.: Production of Congenital Defects in the Offspring of Pregnant Mice Treated with Cortisone. Pediatrics, **8**: 527–533, 1951.
16. Gillman, J.; Gilbert, C.; and Gillman, T.: A Preliminary Report on Hydrocephalus, Spina Bifida and Other Congenital Anomalies in the Rat Produced by Trypan Blue. South African J. Med. Sciences, **13**: 47–90, 1948.
17. Haldane, J. B. S.: Introduction. *In* Biochemical Aspects of Genetics. Biochemical Society Symposia, No. 4. Cambridge, Cambridge University Press, 1950.
18. Hammett, F. S., and Wallace, V. L.: Studies in the Biology of Metals. VII. The Influence of Lead on the Development of the Chick Embryo. J. Exper. Med., **48**: 659–665, 1928.
19. Harris, H. F.: Pellagra. New York, Macmillan Co., 1919.
20. Herrmann, Heinz: Studies on Muscle Development. Ann. New York Acad. Sciences, **55**: 99–108, 1952.
21. Herrmann, Heinz: The Effect of Amino Acid Analogues on the Development of the Explanted Chick Embryo. *In* Prematurity, Congenital Malformation and Birth Injury, pp. 148–160. (Conference at the New York Academy of Medicine, June 1952.) New York, Association for the Aid of Crippled Children, 1953.
22. Hertig, A. T.: Traumatic Abortion and Prenatal Death of the Embryo. *In* Prematurity, Congenital Malformation and Birth Injury, pp. 174–176. (Conference at the New York Academy of Medicine, June 1952.) New York, Association for the Aid of Crippled Children, 1953.

23. Hertig, A. T., and Livingstone, R. G.: Spontaneous, Threatened and Habitual Abortion: Their Pathogenesis and Treatment. New England J. Med., **230**: 797–806, 1944.
24. Hertig, A. T., and Rock, John: A Series of Potentially Abortive Ova Recovered from Fertile Women Prior to the First Missed Menstrual Period. Am. J. Obstet. and Gynec., **58**: 968–988, 1949.
25. Ingalls, T. H.: Preventive Prenatal Pediatrics. *In* Advances in Pediatrics, Vol. VI, pp. 33–62, New York, Interscience Publishers, 1953.
26. Ingalls, T. H.; Curley, F. J.; and Prindle, R. A.: Anoxia as a Cause of Fetal Death and Congenital Defect in the Mouse. Am. J. Dis. Child., **80**: 34–45, 1950.
27. Ingalls, T. H.; Curley, F. J.; and Prindle, R. A.: Experimental Production of Congenital Anomalies. Timing and Degree of Anoxia as Factors Causing Fetal Deaths and Congenital Anomalies in the Mouse. New Engl. J. Med., **247**: 758–768, 1952.
28. Karnofsky, D. A.; Ridgway, L. P.; and Patterson, P. A.: Production of Achondroplasia in the Chick Embryo with Thallium. Proc. Soc. Exper. Biol. and Med., **73**: 255–259, 1950.
29. Karnofsky, D. A.; Ridgway, L. P.; and Patterson, P. A.: Growth-Inhibiting Effect of Cortisone Acetate on the Chick Embryo. Endocrinology, **48**: 596–616, 1951.
30. Karnofsky, D. A., and Ridgway, L. P.: Production of Injury to the Central Nervous System of the Chick Embryo by Lead Salts. J. Pharmacol. and Exper. Therapeut., **104**: 176–186, 1952.
31. Landauer, Walter: Potentiating Effects of Adrenal Cortical Extract on Insulin-Induced Abnormalities of Chick Development. Endocrinology, **41**: 489–493, 1947.
32. Landauer, Walter: The Effect of Nicotinamide and α-Ketoglutaric Acid on the Teratogenic Action of Insulin. J. Exper. Zool., **109**: 283–290, 1948.
33. Landauer, Walter, and Rhodes, M. B.: Further Observations on the Teratogenic Nature of Insulin and Its Modification by Supplementary Treatment. J. Exper. Zool., **119**: 221–261, 1952.
34. Marie, A.: Pellagra. Translated by C. H. Lavinder and J. W. Babcock. Columbia, S. C., State Co. Publishers, 1910.
35. McFarland, Bryan: Pseudarthrosis of the Tibia in Childhood. J. Bone and Joint Surg., **33-B**: 36–46, Feb. 1951.
36. Minot, A. S.: The Physiological Effects of Small Amounts of Lead: An Evaluation of the Lead Hazard of the Average Individual. Physiol. Rev., **18**: 554–575, 1938.
37. Moore, J. R.: Pseudarthrosis of the Tibia and Fibula in Children. J. Internat. Coll. Surg., **9**: 7–13, 1946.
38. Moore, J. R.: Delayed Autogenous Bone Graft in the Treatment of Congenital Pseudarthrosis. J. Bone and Joint Surg., **31-A**. 23–39, Jan. 1949.
39. Morison, J. E.: Foetal and Neonatal Pathology. London, Butterworth and Co., 1952.
40. Najjar, V. A.: Adaptation in Enzyme Systems. *In* Prematurity, Congenital Malformation and Birth Injury, pp. 76–78. (Conference at the New York Academy of Medicine, June 1952.) New York, Association for the Aid of Crippled Children, 1953.
41. Ridgway, L. P.; Patterson, P. A.; and Karnofsky, D. A.: Effect of thallium, lead and other metals on development of chick embryo. Fed. Proc., **9**: 341, 1950.
42. Stockard, C. R.: Developmental Rate and Structural Expression: An Experimental Study of Twins, "Double Monsters" and Single Deformities, and the Interaction among Embryonic Organs during Their Origin and Development. Am. J. Anat., **28**: 115–266, 1921.
43. Tondury, G.: Zum Problem der Embryopathia rubeolosa. Bull. Schweizerischen Akad. d. Med. Wissensch., **7**: 307–325, 1951.
44. Villee, C. A.: Biochemical Differentiation of Human Fetal Tissues with Age. *In* Prematurity, Congenital Malformation and Birth Injury, pp. 79–83. (Conference at the New York Academy of Medicine, June 1952.) New York, Association for the Aid of Crippled Children, 1953.
45. Warkany, Joseph: Etiology of Congenital Malformations. *In* Advances in Pediatrics, Vol. II, pp. 1–63, 1947. New York, Interscience Publishers, 1947.
46. Warkany, Joseph: Experimental Studies on Nutrition in Pregnancy. Obstet. and Gynec. Survey, **3**: 693–703, 1948.
47. Wickes, I. G.: Foetal Defects Following Insulin Coma Therapy in Early Pregnancy. British Med. J., **2**: 1029–1030, 1954.
48. Zwilling, Edgar: Association of Hypoglycemia and Insulin Micromelia in Chick Embryos. J. Exper. Zool., **109**. 197–214, 1948.
49. Zwilling, Edgar: Carbohydrate Metabolism in Insulin-Treated Chick Embryos. Arch. Biochem. and Biophys., **33**: 228–242, 1951.
50. Zwilling, Edgar, and DeBell, J. T.: Micromelia and Growth Retardation as Independent Effects of Sulfanilamide in Chick Embryos. J. Exper. Zool., **115**: 59–81, 1950.

COMPLEMENTARY ROENTGENOGRAPHIC VIEW OF THE HIP

BY THOMAS F. BRODERICK, JR., M.D., BROOKLINE, MASSACHUSETTS

From the Orthopaedic Service, Saint Elizabeth's Hospital, Boston

The simple adjunctive roentgenographic view described herein appears to be a complement of the 45-degree angle roentgenographic study of the pelvis in congenital dislocation of the hip described by Martz and Taylor. This projection was suggested by Dr. William A. Carey, Radiologist at Saint Elizabeth's Hospital, and has been employed over the past five years. In a current article, Ettinger and Elkin refer to this as the Chassard-Lapiné projection and give in detail their use of it in studies of the sigmoid. Chassard and Lapiné developed this exposure in 1923 for measurements of the bi-ischiatic diameter of the pelvis in pelvimetry.

The patient is seated on the x-ray film as shown in Fig. 1, and the x-ray tube is directed toward the pelvis at an obtuse angle of about 120 degrees in relation to the film. Since the descriptive adjective "frog-leg" is commonly applied to the flexion-abduction position, we have bowed further to the genus *Rana* and called this the "leap-frog" position in ignorance of the eponym Chassard-Lapiné.

FIG. 1

Drawing showing the relative positions of the patient and the x-ray tube.

A roentgenogram thus obtained is shown in Figure 2-A, which revealed a congenital dislocation of the left hip in a boy, twenty-two months old. Figure 2-B is a "frog-leg" view made at the same time. Figures 2-C and 2-D show the same hip two years later after effective closed reduction.

This projection is of some value in distinguishing abnormalities of the adult femoral head and acetabulum. Figure 3 is a "leap-frog" view of the left hip in a man, forty-three years old, following a dashboard injury. Conventional anteroposterior and lateral views were not sufficiently informative. Exploration of this hip at the Massachusetts General Hospital revealed a large posterior acetabular fragment impinging on the sciatic nerve and a gouged depression in the cartilage of the femoral head.

It is possible to use this projection in a case of post-traumatic dislocation of the femoral head also, since the relation of hip flexion and adduction on the trunk need not be altered if the patient is supported on the edge of the table.

By varying the obtuseness of the angle of the central ray to the film, one may delineate different portions of the femoral head and acetabulum, much as demonstrated by Martz and Taylor in their complementary approach.

This simple x-ray projection, which was first described by Chassard and Lapiné in 1923, is of definite value in examination of the femoral head and acetabulum.

FIG. 2-A

"Leap-frog" view of congenital dislocation of the hip in a boy, twenty-two months old.

FIG. 2-B

"Frog-leg" view made at the same time.

FIG. 2-C
"Leap-frog" view made two years later, after closed reduction.

FIG. 2-D
"Frog-leg" view made two years later after closed reduction.

FIG. 3

"Leap-frog" view of hip in a man, aged forty-three, following a dashboard injury.

REFERENCES

1. CHASSARD et LAPINE: Étude radiographique de l'arcade pubienne chez la femme enceinte. Une nouvelle méthode d'appréciation du diamètre bi-ischiatique. J. de Radiol. et d'Électrol., **7:** 113–124, 1923.
2. ETTINGER, ALICE, and ELKIN, MILTON: Study of the Sigmoid by Special Roentgenographic Views. Am. J. Roentgenol., **72:** 199–208, 1954.
3. MARTZ, C. D., and TAYLOR, C. C.: The 45-Degree Angle Roentgenographic Study of the Pelvis in Congenital Dislocation of the Hip. J. Bone and Joint Surg., **36-A:** 528–532, June 1954.

DISCUSSION

EARLY WEIGHT-BEARING AND THE CORRECTION OF ANTEVERSION IN THE TREATMENT OF CONGENITAL DISLOCATION OF THE HIP

(Continued from page 245)

Several methods for the measurement of anteversion have been published, all of which we have reviewed and none of which we have used. The method of Dr. Shands and his associates (the Dunlap method) appeals to us as the one which best combines facility and accuracy. We plan to use this method as a check against the more simple method we use and as a means of determining whether spontaneous correction is occurring.

We have discussed the possibility that the firm seating of the head in the acetabulum which has occurred while the patient is in the walking cast might not permit the easy positioning of the femur as required by the Dunlap method; experience, of course, will answer this minor question.

May I suggest in conclusion that the most important thing as regards anteversion is to have it in mind; experience and observation in each case, rather than the exact degree of the deformity, must determine the importance of the anteversion and the need for osteotomy.

THE PLACE OF NERVE-GRAFTING IN ORTHOPAEDIC SURGERY *

BY DONAL BROOKS, F.R.C.S., LONDON, ENGLAND

From the Institute of Orthopaedics, London

The widening scope of orthopaedic surgery makes it necessary for orthopaedic surgeons to interest themselves in the problems associated with nerve repair, in the same way that they became concerned with those of skin coverage and the surgery of blood vessels. It is interesting to note that, during the last War, four of the five Peripheral Nerve Injury Centres in Great Britain were set up in orthopaedic hospitals and were manned by orthopaedic surgeons. In discussing nerve-grafting, I would like to pay tribute to the pioneer work in your country of Bunnell, Ballance, Duel, and Woodhall, in particular, and, in my country, to that of Seddon, Young, Sanders, and St. Clair Strange.

TABLE I

CRITICAL RESECTION LENGTHS (CENTIMETERS)
BASED ON DATA FROM ALL CENTERS

Nerve	High	Intermediate	Low
Median			
Motor	7	8.5	7
Sensory	7	9	7.5
Ulnar	10	13	10
Radial	8	8	7.5
Lateral popliteal	9	9	9
Medial popliteal	10	11	7

As nerve-grafting now occupies an established place in the surgery of peripheral nerves, it may be profitable to examine the present-day scope of this operation. The following observations are based on a review of ninety-three patients who have been treated during the last twelve years in one center by Mr. H. J. Seddon and his team.

THE NECESSITY FOR NERVE-GRAFTING

End-to-end suture still remains the method of choice in the repair of divided nerves. Under what circumstances, therefore, is nerve-grafting necessary? The answer is when nerve suture is either impossible or undesirable.

Too Large a Gap

Even though it may be technically possible to close extensive gaps by full mobilization of the proximal and distal stumps with acute flexion of one or more joints, the fact is that, during postoperative stretching, a traction lesion is often inflicted on the nerve with subsequent intraneural fibrosis and little or no recovery. Therefore, there is a biological rather than an anatomical limiting factor. Accumulated data from the five wartime Peripheral Nerve Injury Centres have made it possible to compile a table of "critical resection lengths" (Table I) relating to each nerve. These measurements should be regarded as outside limits only. A useful working rule is that a nerve graft should be employed if the gap after mobilization cannot be closed by flexion of the main joint to a right angle, as, for example, the knee joint in the case of the sciatic nerve and the elbow in lesions of the median and ulnar nerves.

* Read at the Annual Meeting of The American Orthopaedic Association, Bretton Woods, New Hampshire, June 10, 1954.

Partial Lesions

It is not uncommon to find a partial lesion of the median nerve following a laceration in the front of the wrist joint. This may result in either the sparing of the motor branch to the thenar muscles with almost complete sensory loss or *vice versa*. Exploration of the nerve frequently reveals a well developed lateral neuroma in relation to intact nerve fibers. After the epineurium has been incised longitudinally, it is possible to separate damaged fibers from undamaged fibers and to resect the neuroma. Formerly, the nerve was repaired by so-called loop suture, which is untidy in that no epineural sutures can be inserted on the internal surface of the nerve because there is no epineurium. In these circumstances the gap can be neatly bridged by means of an inlay graft.

Extenuating Circumstances

In many hand injuries with concomitant nerve and tendon damage, the optimal position of joint flexion for tendon repair rarely coincides with that suitable for nerve suture. Nerve-grafting provides a means of overcoming this difficulty. Similarly, joint stiffness, in some instances, interferes with the usual method of nerve mobilization, and grafting is then the only means available for restoring continuity of the nerve.

PRINCIPLES OF NERVE-GRAFTING

To most surgeons, the chief objection to nerve-grafting is its dismal record in the past. It is important, therefore, to consider the possible causes of failure. These may be conveniently reviewed under two headings: technical and theoretical objections.

Technical Objections

There is no doubt that many of the early attempts at nerve-grafting were unsuccessful simply from the failure to appreciate the principles that apply to all peripheral-nerve surgery. For example, nerves were frequently repaired many months or even years after the original injury, when irreversible changes had taken place in paralyzed muscles that precluded any hope of motor recovery occurring. Resection of the neuroma was often inadequate; thereby axonal regeneration was hindered. A single strand of a cutaneous nerve was used to bridge a gap in a main-nerve trunk, thus seriously limiting the number of regenerating axons. Finally, the use of homografts, which had proved so successful in animal experiments, was found to be quite useless in man, largely on account of the reaction of immunity which they produced. [8, 10]

Theoretical Objections

In addition to the technical faults which I have outlined, failure was attributed to many hypothetical causes. In most instances, cutaneous nerves are used to provide grafting material. It was suggested that the small fiber diameter of sensory nerves would not allow the large motor fibers to attain a functionally adequate diameter, whereas in fact it has been demonstrated that regenerating motor fibers can inflate these smaller tubes.[9]

Free nerve grafts are revascularized across their suture lines and also from the bed in which they lie. In the early stages, this latter means of survival is probably the more important of the two. The metabolic requirements of a graft in which the axons and myelin are still present were thought to be higher than one in which these materials had been removed previously by phagocytosis. It was argued, therefore, that predegenerate grafting material should be used in preference to normal nerve. However, it has been shown that the use of predegenerate grafts is no more successful than the use of those taken from the proximal stump.

Again, it was thought that, whereas axons might traverse the proximal suture line

into the graft, their progress was subsequently barred by fibrous invasion at the distal suture line from the surrounding tissues. It was suggested by Davis and Cleveland that the time taken for the axons to traverse the graft should be calculated and at the time they were reckoned to have reached the distal line a resection and suture at this level should be undertaken. Moreover, it was recommended that, in order to prevent a fibrous invasion of the suture line, it should be wrapped with tantalum foil. However, the histological work of Abercrombie and others has shown that Schwann-cell activity is greatest in the distal stump so that the distal junction is in fact the better of the two. Furthermore, surrounding the suture line with tantalum foil defeats its own object, not only by provoking a fibrous reaction but also by isolating part of the graft from its vascular bed. It is possible that the alleged fibrous invasion of the distal suture line was in fact due to a partial separation, for it is known that considerable shortening of a free graft occurs after transplantation.

Having examined some of the causes of failure in the past we have been enabled to evolve a series of working rules:

1. The general principles that apply to all peripheral-nerve surgery with regard to the adequacy of resection and the time that has elapsed since injury must be observed;
2. The cross-section area of the graft or grafts must equal that of the nerve to be repaired;
3. The graft should be 12 to 15 per cent. longer than the gap to be filled, in order to allow for shrinkage;
4. The bed for the graft must be free from scar tissue to facilitate revascularization.

OPERATIVE TECHNIQUE

Donor Nerves

Cutaneous nerves are usually employed for grafting material. The common donors in the upper limb are the medial cutaneous nerve of the forearm taken from the upper arm and the superficial branch of the radial nerve in the forearm; in the lower limb the donors are the saphenous and sural nerves. These nerves all have a cross-section diameter of two or three millimeters and yield an average of twenty to thirty centimeters of graft before breaking up into their terminal branches.

It sometimes happens that two main nerves are extensively damaged at the same time; in these circumstances the less important nerve may be used to graft the other. Very occasionally, a main nerve is split longitudinally and the less important half is used as a graft.

Types of Graft

There are four types of nerve graft:

1. Digital—free graft;
2. Inlay—free graft;
3. Cable—free graft;
4. Main trunk—free and pedicle grafts.

Digital Grafts

Digital grafts are single strands of a cutaneous nerve used for the repair of digital nerves or the deep branch of the ulnar nerve. In all instances, they are free grafts. The bed in which they lie, therefore, should be free from scar tissue. Fixation is best secured by "glueing" the ends with plasma clot; care must be taken to localize the clots to the suture lines as otherwise revascularization is impeded. We have not found it necessary to employ Tarlov's molds when we use plasma, and rely on posturing to control and localize pooling before the plasma sets.

Inlay Grafts

In partial lesions of a main nerve with a well developed lateral neuroma the damaged fibers are carefully split off from the others, the neuroma is resected, and a strand or strands of graft is inserted in the gap and is secured by plasma clot.

Cable Grafts

The cable graft is used for restoring continuity in main nerves, such as the median nerve or the upper trunk of the brachial plexus. It has been emphasized before that the cross-section area of the cable graft must equal that of the main trunk. In nerves of large diameter, therefore, a considerable length of grafting material may be necessary. We have never considered it justifiable to use more than one donor nerve in any given case. This means that it is often necessary to carry out a full mobilization of the nerve with optimal flexion of the main joint, in addition to cable-grafting. Fixation of the grafts is effected by plasma clot.

Main-Trunk Grafts

This type of nerve-grafting is necessarily restricted in its use, as it implies simultaneous damage to two main nerves. It also implies that direct suture of either nerve is impracticable. Nevertheless, we have seen several war injuries in which an explosion, taking place at close quarters, had blown away considerable lengths of the median and ulnar nerves. Industrial accidents are often associated with similar injuries of the forearm, with destruction of skin, muscles, blood vessels, and nerves. Clearly, in these instances, restoration of continuity by direct suture is not possible. The nerve subserving the less important function is, therefore, used to graft its fellow. In the upper limb the ulnar nerve is sacrificed for the median and in the lower limb the lateral popliteal is used for the repair of the medial popliteal in order to restore protective sensibility to the sole of the foot. In such cases a free graft taken from one, usually the proximal, stump of the donor nerve is sutured into position, interrupted epineural sutures of some non-absorbable material, such as fine white silk or human hair, being used. If the bed for the graft is poor, it is often possible to by-pass it through healthy tissue. The longest free graft of this type that we have used has been seventeen centimeters in length—a case in which the ulnar nerve was used to graft the median.

In severe Volkmann's ischaemia of the forearm muscles when both the median and ulnar nerves are involved, clearly such a free graft could not survive. It has been shown by Seddon and others that the nerve lesion in these instances is ischaemic in origin and affects a considerable segment of the nerve.

It is in these very severe lesions, in which conditions for free grafting could hardly be worse, that the pedicle nerve graft described by St. Clair Strange has proved so promising. The principles of pedicle nerve-grafting are similar to those that apply to grafting of skin. At the first stage, the proximal neuromata of both nerves are resected and the ends sutured together. The length of the gap to be closed is calculated, and shrinkage is allowed for. The less important nerve is then divided proximally at the required distance from the suture line. If possible, the small epineural vessels are left intact, and, of course, the graft is left undisturbed in its surrounding tissues. The second stage is carried out six weeks later, at which time the graft is turned down as a pedicle and passed subcutaneously down the forearm to the wrist. The distal suture is then carried out. It is noteworthy that, in the five patients in whom we have used this method, the graft has bled freely after resection. In all patients in whom this method of repair has been used, excellent recovery has occurred. This means that light touch and pin-prick sensibility were restored throughout the median area of the hand and voluntary power was restored in the thenar muscles. A tendon transfer of the wrist extensors into the finger flexors at a later date improved the function of the limbs.

TABLE II

AUTOGENOUS NERVE GRAFTS: SUMMARY OF RESULTS (1941–1954)

	Recovery	Recovering	Partial Recovery	Failure	Not Traced	Total
Digital	8		3	6		17
Cable						
Median	7		4	1		12
Brachial plexus		1	2	3		6
Others	4		2			6
Main trunk						
Median	16		3	2		21
Sciatic	1		3	5		9
Others	1			4		5
Pedicle	5					5
Inlay	9	1		1	1	12
Total	51	2	17	22	1	93

RESULTS

Table II summarizes the results of ninety-three cases in which nerve-grafting was used to restore continuity of a nerve. The significant features are: (1) in the limited number of pedicle nerve grafts, an excellent recovery has been made in all patients; (2) the results of sciatic nerve-grafting have been consistently poor; (3) digital nerve-grafting has been uncertain in its results. Lastly, all other forms of nerve-grafting have given useful recovery in over 50 per cent. of the patients. By definition a successful recovery means a result as good as the best result seen after an injury of the same nerve at the same level repaired by end-to-end suture carried out under favorable conditions

I think it is fair to conclude that the most important single factor contributing to the success of a nerve graft must be adequate revascularization of the graft. In grafts of large diameter, such as those of the sciatic nerve, rapid revascularization rarely occurs. If, however, pedicle nerve-grafting is employed, then survival is assured. In cable and digital grafts, it is essential to ensure that conditions for revascularization are as favorable as possible. In the forearm, this is relatively simple, as the grafts can be surrounded by vascular muscle bellies. In the hand, however, with a limited amount of subcutaneous tissue, and surrounded by the long flexor tendons, the conditions for survival of a free graft are poor. Furthermore, Seddon has shown that in digital-nerve injuries, the digital vessels are often injured at the same time, which may give rise, on occasions, to an ischaemic lesion of the distal segment of the nerve.

In conclusion, nerve-grafting is a technique that requires meticulous attention to detail; but it is one that, with a knowledge of the principles which apply to all peripheral-nerve surgery, can yield results which are very rewarding and which often must be an essential step in an orthopaedic reconstruction program.

REFERENCES

1. ABERCROMBIE, M., and JOHNSON, M. L.: The Outwandering of Cells in Tissue Cultures of Nerves Undergoing Wallerian Degeneration. J. Exper. Biol., **19**: 266–283, 1942.
2. BALLANCE, CHARLES, and DUEL, A. M.: Operative Treatment of Facial Palsy by the Introduction of Nerve Grafts into the Fallopian Canal and by other Intratemporal Methods. Arch. Otolaryngol., **15**: 1–70, 1932.
3. BUNNELL, STERLING: Surgery of the Nerves of the Hand. Surg., Gynec., and Obstet., **44**: 145–152, 1927.
4. DAVIS, L., and CLEVELAND, D. A.: Experimental Studies in Nerve Transplants. Ann. Surg., **99**: 271–183, 1934.
5. SANDERS, F. K.: The Repair of Large Gaps in Peripheral Nerves. Brain, **65**: 281–337, 1942.
6. SEDDON, H. J.: Three Types of Nerve Surgery. Brain, **66**: 237–288, 1943.

7. Seddon, H. J.: The Use of Autogenous Grafts for the Repair of Large Gaps in Peripheral Nerves. British J. Surg., **35:** 151–167, 1947.
8. Seddon, H. J., and Holmes, W.: Ischaemic Damage in the Peripheral Stump of a Divided Nerve. British J. Surg., **32:** 389–391, 1944.
9. Simpson, S. A., and Young, J. Z.: Regeneration of Fibre Diameter after Cross-Unions of Visceral and Somatic Nerves. J. Anat., **79:** 48–65, 1945.
10. Spurling, R. G.; Lyons, W. R.; Whitcomb, B. B.; and Woodhall, Barnes: The Failure of Whole Fresh Homogenous Nerve Grafts in Man. J. Neurosurg., **2:** 79–101, 1945.
11. Strange, G. F. St. C.: An Operation for Nerve Pedicle Grafting. Preliminary Communication. British J. Surg., **34:** 423–425, 1947.
12. Tarlov, I. M.: Plasma Clot Suture of Peripheral Nerves and Nerve Roots. Springfield, Illinois, Charles C. Thomas, 1950.
13. Young, J. Z., and Medawar, P. B.: Fibrin Suture of the Peripheral Nerves. Measurement of the Rate of Regeneration. Lancet, **2:** 126–128, 1940.

DISCUSSION

Dr. Barnes Woodhall, Durham, North Carolina: As Mr. Brooks has pointed out, in World War II in England, peripheral-nerve repair was almost entirely the responsibility of orthopaedic surgeons. In this country, on the contrary, following our own inherited traditions, this task was invested in neurosurgeons. We perhaps gained this honor by default, since, at that time, it seemed to me, our orthopaedic surgeons had their hands full with other and very formidable jobs. In retrospect, this may have been a poor decision, since we are not primarily extremity surgeons. We did learn, however, the very important lesson—this has been developed at some length in our report on peripheral-nerve regeneration—that there really is no such thing as peripheral-nerve surgery alone, or *per se*, but that it is simply part of what might be termed total limb surgery.

TABLE A

Degree of Motor Recovery in Individual Muscles in Complete High and Low Median-Nerve Sutures

Muscle	No Contraction	Contraction not against Resistance	Contraction against Resistance	Mean Dynamometer Values as Percentage of Normal
Flexor pollicis longus	8.57	11.43	80.00	44.24
Flexor indicis	5.88	9.80	84.32	50.31
Abductor pollicis brevis	17.19	32.81	50.00	15.00

From this point of view, it has been our tendency in recent years to consider nerve-grafting as a specialized phase of limb surgery which may be applied to some very specific demand of limb surgery. This requirement would be one that could not be answered by some other and perhaps better aspect of limb rehabilitation, be it tendon transfer, arthrodesis, or the use of braces. This point of view may be contrasted to that which seeks everything possible from nerve repair itself, with more interest in anatomical regeneration than functional regeneration. Although this is a very simplified expression of the problem, I am sure that Mr. Brooks is sympathetic with this opinion and undoubtedly pursues it himself.

I would then add to Mr. Brooks' indications for nerve-grafting the functional demands of the extremity in specific patients and in terms of other means of rehabilitation. Thus in irreparable injuries of the radial nerve, we would suggest tendon transplantations rather than nerve-grafting. Because of our results in nerve-suturing in World War II, we would not be too hopeful concerning the return of intrinsic-muscle func-

TABLE B

Degree of Motor Recovery in Individual Muscles in Complete High and Low Ulnar-Nerve Lesions Following Suture

Muscle	No Contraction	Contraction not against Resistance	Contraction against Resistance	Mean Dynamometer Values as Percentage of Normal
Flexor digitorum profundus	4.95	14.85	80.20	38.65
Abductor digiti quinti	9.60	44.44	45.96	12.55
First dorsal interosseus	13.16	40.13	46.71	13.16

TABLE C

PAIN THRESHOLD (PIN PRICK)

Median	None or Deep Pressure Only	20 to 40 Grams	6 to 10 Grams	Total
High Sutures	30	40	44	114
Low Sutures	22	33	53	108
Total	52 (23 per cent.)	73 (33 per cent.)	97 (44 per cent.)	222

tion in the hand after nerve-grafting. Table A lists the results of 513 median-nerve sutures, admittedly gunshot wounds and treated at varying time periods after injury.

For the ulnar-nerve sutures the findings listed in Table B were noted.

Although these data are derived from a study of severe injuries and represent probably minimal results, we would tend to resort to orthopaedic measures rather than to nerve-grafting for the restoration of the hand effector mechanism.

As far as the restoration of sensation is concerned, we would wholly agree with Mr. Brooks, that this is one area in which the orthopaedic surgeon cannot wield his magic with the use of tendon and bone. Nerve-grafting is the only answer for irreparable injuries, particularly those of the median and digital nerves, in which sensory function is so important to the hand. We are further encouraged to this end by the much better results noted in the return of pain appreciation than motor power in this same group of median-nerve injuries. At least 75 per cent. of these patients gained useful pain sensory return (Table C) and the same result was noted in the modality of touch.

The techniques described by Mr. Brooks are fine and are to be restricted to autogenous nerve-grafting. We wasted many months with the various methods of homogenous nerve-grafting in man. They all failed, and once again it was proved that man cannot be compared to the rabbit, the cat, or even the monkey in peripheral-nerve repair. We might quibble about the very tidy technique of plasma suture since we have definite evidence in our regeneration study that plasma-glue sutures did less well than other types of suture. It is perhaps a minor matter.

The second major interest in nerve-grafting lies in the rehabilitation of the severe injuries that I have called in the past "pre-amputation limbs". Here the use of the St. Clair Strange technique, described in this country by Selverstone, is very worth-while. Time does not permit a detailed examination of this problem in the lower extremity. I might say we have been poorly impressed by the quality of the sensory return in sciatic-nerve sutures and tibial-nerve sutures. The resulting dysaesthesia may often be more of a handicap than the pre-existing anaesthesia. We have not used nerve-grafts in many lower-extremity injuries.

All in all, we may have set our sights too low. This significant statement of results by Mr. Brooks may force us to re-examine our thinking in this matter which may have been in the past far too conservative.

DR. ERIK MOBERG, GÖTEBURG, SWEDEN: Though we have had much less experience in nerve repair by means of grafts in the hand and arm, we have had a number of patients in whom, following the suggestions of the Seddon group, we have been able to restore *motor function* to an extent which has astonished us. In other patients in whom sensibility was to be restored, however, we have almost always been disappointed with our results. This is true whether grafts were used or whether a simple nerve suture was done. We were able to restore cotton-wool and pin-prick sensation and some sudomotor function, and we were able to improve the two-point discrimination. In a few patients with very good results the Seddon coin test also showed return to a minor degree of stereognosis. However, our patients could not use the repaired parts of their hands in skilled manual work, because of the lack of stereognosis.

There are different degrees of stereognosis. As early as 1826 Sir Charles Bell pointed out that it is possible to feel the pulse with the finger tips but not with the tongue. Two-point discrimination, however, is very much the same in the tongue and in the finger. Better tests than we now have must be found in order that we may judge how much the regained sensibility is worth to the working ability of the patients.

[A short motion picture was shown in which sensation was tested by letting the patients pick up small things with their eyes open or closed.] With the help of such tests we have found that only in a few young patients, in whom repair of the median nerve had been performed under the most favorable conditions, was there a return of stereognosis to such a degree that the patients could use their fingers in a normal way.

We know that when motor nerves are damaged, transfer of tendons is often the method of choice for the repair. There is a similar way to restore stereognosis—*the transfer of sensation* by means of a neuro-vascular flap. In our opinion this method should be taken into consideration when discussing nerve-grafting for the repair of sensibility.

[Lantern slides were shown of patients in whom sensation had been transferred from the ulnar side of

(Continued on page 326)

COMPLICATIONS AND FAILURES IN THE OPERATIVE TREATMENT OF INTERTROCHANTERIC FRACTURES OF THE FEMUR*†

BY G. MOSSER TAYLOR, M.D., ALONZO J. NEUFELD, M.D., AND VERNON L. NICKEL, M.D.,
LOS ANGELES, CALIFORNIA

From the Departments of Orthopaedic Surgery, College of Medical Evangelists, and the Los Angeles County Hospital, Los Angeles

Although it is only about fifteen years since the introduction of internal fixation for intertrochanteric fractures of the femur, at the present time this method is the treatment of choice in the management of the majority of these fractures. Comparable results by conservative methods are observed only when such lesions receive the expert care available in a few highly specialized medical centers.

Since 1939, about 3,000 patients on the different services at the Los Angeles County Hospital have been operated upon with use of internal fixation. From June 1948 to June 1952, a total of 1,469 patients were so treated at the Los Angeles County Hospital, an average of 367 cases of trochanteric fractures operated upon each year. In addition, 650 private patients have been so treated. The femoral nail-plate, described in a previous article [4], has been the fixation device generally applied.

FIG. 1

The roentgenogram shows a nail which is too long.

Of these 3,650 cases of trochanteric fractures treated by open reduction, only 1,500 had roentgenographic follow-up studies adequate for evaluation for this review. Of the 1,500 cases, 123 showed marked deviations from what could be considered acceptable restorations. These latter cases were studied in detail. They included all the various types of complications and failures in the same relative frequency as were found in the whole series. Similar defects were seen in cases not included here, but these were not serious enough to cause appreciable interference with function. No attempt was made to make a complete statistical analysis of all cases, for other studies have done this and have included mortality figures and the incidence of such well known surgical complications as infection, embolism, and pneumonia [1,2,3].

The present discussion will summarize the most frequent complications, point out the causes of the failures, and, as far as possible, suggest techniques for their prevention and correction. The various problems will be discussed in the order of frequency with which they occurred.

The chief impression gained from such a study is that the causes of operative complications and failures are manifold. In the final analysis, however, the responsibility rests with the surgeon.

* Read in abbreviated form at the Annual Meeting of The American Academy of Orthopaedic Surgeons, Chicago, Illinois, January 26, 1953.

† Revised manuscript received for publication September 3, 1954.

FIG. 2-A

FIG. 2-B

E. M., a woman, eighty-two years old, with advanced senile osteoporosis, had satisfactory reduction and nailing on November 16, 1951. (Fig. 2-B has been retouched.)

FIG. 2-C
November 25, 1951

FIG. 2-D
June 1952

Nine days after nailing the patient complained of severe pain in the hip; external rotation and shortening were noted. Roentgenograms showed that the nail had cut through the osteoporotic bone, with ensuing loss of reduction. A spica abduction cast was applied. The nail was removed after healing was complete. Clinically, the result was a moderate limp, but the patient had only a mild degree of discomfort.

Late Penetration of Acetabulum Following Use of Too Long Nail

One of the most frequently encountered complications resulted from the use of a nail which was too long (Fig. 1). In almost one third of the 123 patients with complications the nail selected was too long and had penetrated the acetabulum. Fortunately, the majority of these fractures healed with good function. It was surprising to find how far the nail had penetrated into the acetabulum in some cases, without causing the patient undue pain or discomfort. Furthermore, after removal of the nail, there was but a slight amount of symptomatic degenerative arthritis. These findings emphasize the necessity for leaving the nail in place until there is solid union at the fracture site.

Ideally, the nail should penetrate the head no further than one centimeter from the articular margin as seen in both anteroposterior and lateral roentgenograms; thus, nail lengths of three or three and one-half inches are adequate for most patients.

FIG. 3

The nail was too short for adequate fixation.

Disruption of Internal Fixation and Loss of Reduction

This complication, which occurred chiefly when the bone of the femoral neck was osteoporotic, usually took place several days after the internal fixation (Figs. 2-A to 2-D). Attempts at operative correction of

FIG. 4

FIG. 5

Fig. 4: In this case, too short a plate had been used, resulting in disruption of the fracture. The patient had been allowed to put too much weight on the extremity.

Fig. 5: Medial migration of nail with penetration across the hip joint.

this complication were at times difficult and often ineffective. However, if the deformity following disruption is too great and cannot be reduced satisfactorily by closed methods, reoperation may be indicated. In either event, some method of external immobilization must be used during most of the period of convalescence, or even until bony union has been obtained.

If at operation the bone is noted to be very soft, it is advisable to employ some form of external fixation for four to eight weeks postoperatively and to be extremely cautious as to the amount of activity permitted these patients. These considerations apply particularly to patients with severe spasm, such as that associated with paralysis agitans. Similar care is also indicated when internal fixation is not secure, as frequently happens if severe comminution is present.

If it appears that external fixation must be used for six to eight weeks or more because of comminution or osteoporosis, internal fixation should not be attempted. The exception to this exists when it is impossible to secure or to maintain satisfactory reduction by other means; this may occur in many subtrochanteric fractures and, rarely, in trochanteric fractures.

In the present series of cases, it was noted that loss of fixation occasionally occurred when the nail was too short (Fig. 3) or when a severely comminuted intertrochanteric fracture was secured with too short a plate (Fig. 4). For fixation of the plate it is essential that the screws be inserted in drill holes of the proper size and in more than one plane; the subtrochanteric region may require extra screws. Circumferential wires or even anterior plating occasionally may be indicated in addition.

No matter how well applied, metal internal fixation should never be considered as a substitute for intact bone. The apparatus serves only as an internal splint to maintain alignment until new bone can form in an amount sufficient to carry the patient's weight.

Deformities Due to Inadequate Reduction

The deformities resulting from inadequate reduction of intertrochanteric fractures were: coxa vara, external or occasionally internal rotation of the distal fragment, and infrequently coxa valga. A valgus deformity is never marked and is seldom incapacitating. Usually it is found during surgery, at which time it is easily corrected.

Coxa vara was the most common deformity in this series. If severe—that is, 110 degrees or more—the disability was considerable, characterized by pain and weakness of the hip, as well as shortening of the extremity. Rotational deformities were disabling only if severe enough to make it difficult for the patient to place the foot in a normal position when walking. Because of the effect of gravity, external rotation is the most commonly encountered rotational deformity. This can be avoided by manually lifting and rotating the distal fragment into the normal anatomical position at operation.

Medial Migration of the Femoral Shaft with Penetration of the Nail into or across the Hip Joint

Medial migration of the femoral shaft pushing the nail through the head frequently occurred after fixation of fractures located at the junction of the intertrochanteric and subtrochanteric regions with separation of the lesser trochanter. This was especially true when the fracture line was in the plane of the lower border of the femoral neck (Fig. 5). The same result occurred when, because of rough handling, the lateral cortex of the trochanter was broken at the point where the nail was inserted.

An effective device for preventing this medial drift is an auxiliary plate which extends upward above the base of the nail so as to abut against the greater trochanter when displacement occurs. This additional plate was first described by Boyd and Griffin[1]. Figures 6-A and 6-B illustrate the effectiveness of this mechanism. As an expedient, an ordinary malleable bone plate can be modified for this purpose.

FIG. 6-A
January 25, 1951

FIG. 6-B
January 29, 1951

Roentgenograms showing use of the auxiliary plate to prevent medial migration of the femoral shaft. This is the method worked out by Boyd and Richardson [1]. (Fig. 6-A has been retouched.)

Delayed Union with Occasional Breaking of the Nail

In the few cases in which the nail broke, delayed union was present.

In all fractures in which internal fixation is used, the rate of healing is materially slowed. In fractures of the femur in the trochanteric region, instead of the three to four months usually required for union by closed methods, from five to seven months are required for union when internal fixation is used. Failure to recognize the principle of slow healing in the presence of a foreign body and a tendency to succumb to the false sense of security which comes with internal fixation are responsible for most mechanical failures. The nail may not break until as late as the eighth month or more of convalescence. The prevention of this complication demands understanding on the part of the surgeon and firm adherence to instructions on the part of the patient.

Fractures at the base of the neck showed a predisposition to delayed union and often non-union, particularly those treated by closed methods. In an incompletely immobilized fracture of this type, especially if the patient is active, the hard cortical bone of the neck tends to grind against the mushy cancellous bone of the trochanteric region, resulting in absorption and hollowing out of the cortical shell of the greater trochanter.

With internal fixation, delayed union appeared at every level, but especially in the low trochanteric area.

Reoperation was usually carried out when union was delayed and the nail was broken. In the event of non-union, operation was, of course, imperative. If reoperation is necessary, the new nail should be inserted in such a way that minimal stresses on the metal will result. Even during the original insertion, if the plate is bent to fit the plane of the femoral shaft, persistent work stress may result in breakage along the line of the so-called "crystallization" of the metal. In addition to the repinning, massive amounts of cancellous bone, and, at times, cortical bone should be applied as grafts. Repair of non-union in this area is a difficult procedure, involving resection of sclerotic bone followed by reduction and stabilization of the atrophic proximal fragment.

FIG. 7-A
January 2, 1950

FIG. 7-B
March 27, 1950

C. J., a woman, seventy-eight years old, started walking too early after insertion of the nail-plate, and six weeks after operation the nail broke. It was refixed with a femoral nail-plate. An additional plate and tibial grafts from the bone bank, together with a large amount of cancellous bone from the bone bank, were used. To complicate the management, the patient had a serious cardiac condition. The fracture healed and the patient walked well for over three years until her death.

This case illustrates an important point: If a second operation is necessary on intertrochanteric fractures, additional bone should be used liberally and fixation should be solid.

The cases illustrated in Figures 7-A through 8-F provide excellent examples of what happens to the reduction of the fracture, to the internal fixation, and to the ultimate function when protection and caution are neglected before solid bony union has been established.

As a result of this study a few suggestions relative to the postoperative management of these fractures may be offered in the hope of lowering the incidence of this and other complications. How much active motion may be permitted and how soon must be decided by the surgeon on the basis of his knowledge of the type and stability of the hip after fixation. Pain, of course, is usually but not always a contra-indication to active motion. The patient may be placed in a wheel chair after the first five to ten days, or not for two or more weeks. Walking is begun with the aid of attendants, a walker, or crutches. The average elderly person is not strong enough for the use of crutches and must depend upon the other means of support when beginning weight-bearing. At first, the patient may rest his foot on the floor, leaning his weight on the attendants or on the walker while shifting his weight to the well side in taking a step. Gradually more and more weight is permitted, but full weight-bearing should not be allowed until there is definite roentgenographic evidence of trabeculation of the callus across the fracture line. Anteroposterior and lateral roentgenograms made with a rotating anode x-ray tube with a fine focal spot are needed for accurate interpretation. Even then, irregular, fine defects due to delayed

union or non-union will confuse the most experienced. Pain persisting or increasing is a clue pointing to faulty union.

INFREQUENT COMPLICATING CONDITIONS IN THE TREATMENT OF TROCHANTERIC FRACTURES

Incompleted Operation

Attempts to nail severely comminuted intertrochanteric fractures were occasionally completely unsuccessful at the very outset. In such instances, the nail had to be removed and the patient had to be returned to bed for treatment by some non-surgical method such as a cast or traction.

Although a good roentgenographic examination will usually indicate the presence of comminution, inadequate roentgenograms will certainly leave the surgeon unprepared for the situation revealed at surgery. The greater trochanter may be split in the coronal plane, the fracture line extending obliquely into the region of the femoral shaft just at the point where the nail should be inserted. Marked comminution and multiple insertions of the nail may combine to make fixation virtually impossible.

Refusal or Inability to Return to Weight-Bearing

Some patients, occasionally because of pain but more often because of an abnormal anxiety or fear, refused to bear weight on the affected extremity. They went around in their walkers or, if they were strong enough, they bore weight on the sound extremity and used crutches. The result was osteoporosis of a severe degree, usually associated with contractures.

Neurotrophic Disturbances

Neurotrophic disturbances, such as tabes dorsalis, were often not recognized before surgery in these elderly patients. Internal fixation in the presence of such disorders accomplished nothing and tended to hasten the disorganization of the joint (Fig. 9).

Intertrochanteric fractures in the presence of spasticity, as in paralysis agitans, required additional external support to maintain reduction. An adductor myotomy decreased the stress on the fracture site in these cases.

Avascular Necrosis

Avascular necrosis due to loss of blood supply to the entire proximal fragment, including the neck and head, as might be expected, in these trochanteric fractures was rare. Only one case seemed to show definite avascular necrosis, while another showed questionable changes. Neither of these patients had been treated surgically, and the cause of the aseptic necrosis was not apparent.

OPERATIVE TECHNIQUE

In the authors' experience, operation is facilitated by the use of either a standard operating table or a wheeled stretcher instead of a fracture table. The involved extremity is draped free, so that the necessary freedom for reduction is allowed. A more accurate roentgenogram in the lateral plane may be obtained in the flexed or frog-leg position. As described in a previous paper [4], the most effective way to expose the lateral surface of the upper femoral shaft is to pull the mass of the vastus lateralis forward and to incise it 1.5 centimeters from the linea aspera. A single Bennett-type retractor will then afford excellent exposure (Fig. 10), holding all the muscles anteriorly.

The location of the half-inch drill hole made for the insertion of the nail is of great importance. It is best located 1.5 centimeters below the lower border of the greater trochanter, or at the level of the lesser trochanter, depending upon the normal angle as

FIG. 8-A
September 1949

FIG. 8-B
January 1950

Fig. 8-A: J. H., a woman, fifty-five years old. Her fractured hip had been operated upon and had been transfixed in good position. The patient was permitted to walk early.
Fig. 8-B: Roentgenograms made after a three-month interval revealed definite delayed union.

FIG. 8-C
March 1950

FIG. 8-D
January 1951

Fig. 8-C: Activity was continued and the nail broke.
Fig. 8-D: Roentgenogram made after the second operation, performed in November 1950.

FIG. 8-E
July 1951

FIG. 8-F
September 1951

Fig. 8-E: Twenty-one months after the original fracture and nine months after reoperation the patient was again advised to begin weight-bearing. The result, as might have been expected, was a broken nail and coxa vara.

Fig. 8-F: Two years after the original fracture, a displacement osteotomy was finally performed. Clinical examination during the third year after the fracture revealed considerable pain in the hip and marked stiffness of the knee.

In this case, when delayed union first became evident, bone-grafting and additional fixation should have been done, and the patient should have been warned to avoid weight-bearing.

FIG. 9

Fig. 9: In this patient, tabes dorsalis hastened complete disorganization. (The roentgenogram has been retouched.)

estimated on the well side (provided that the anteroposterior roentgenogram is made with the hip in internal rotation to secure a true profile). Care is necessary to avoid further fracturing of the lateral cortex while drilling or using an osteotome. Rough manipulation must be avoided to guard against further comminution.

Reduction is usually obtained when the thigh is held in 20 degrees of flexion and 20 degrees of abduction and in an approximately neutral position of rotation. By grasping the extremity at the flexed knee, the surgeon can hold this position and apply traction. Usually this force need not be great to obtain the normal angle of the neck. After the direct manual reduction of the fragments through the wound, the limb is held by the assistant in the proper position while the nail is inserted. The placement of the nail is simplified

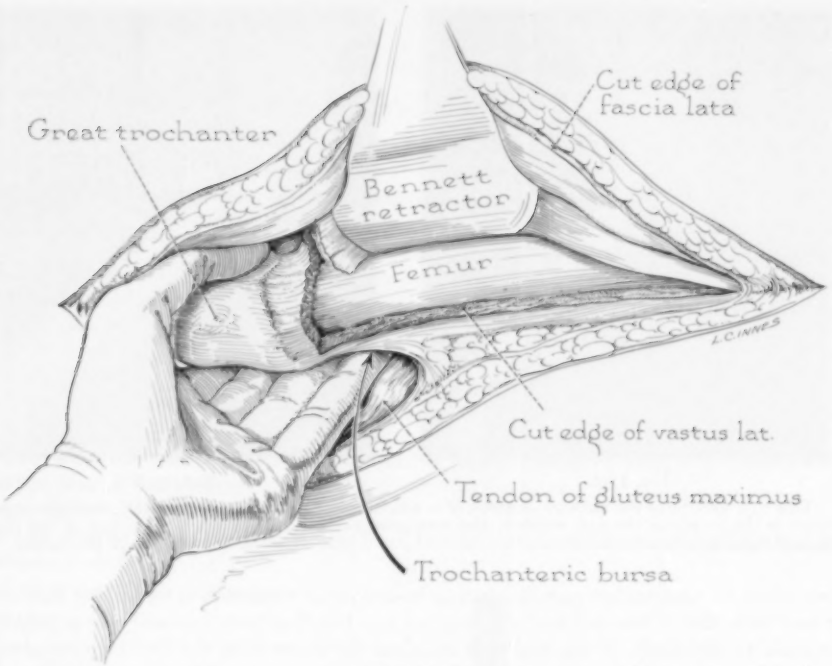


FIG. 10

Drawing demonstrating manual manipulation of fragments and orientation for correct insertion of the nail.

if the operator is able to grasp the trochanteric region anteriorly and posteriorly between his thumb and fingers, in order to support the fragment and to prevent posterior displacement. The index finger is used to locate the direction and the plane of the neck fragment; this gives the surgeon an excellent guide for insertion of the nail. The authors consider that this manoeuvre, which supports the fragments and gives orientation for insertion of the nail, is one of the most important steps in the operative technique.

In these elderly patients the nail should penetrate without much effort as far as the more dense cancellous bone of the head. The plane of the plate and the plane of the femoral

TABLE I

FREQUENT COMPLICATIONS AND FAILURES OF INTERNAL FIXATION OF TROCHANTERIC FRACTURES

Complications	No. of Cases	Frequency among 123 Cases (*Per cent.*)	Frequency among 1,500 Cases (*Per cent.*)
Late penetration of acetabulum following use of too long a nail	36	29.2	2.4
Disruption of internal fixation and loss of reduction	26	21.1	1.7
Deformities due to inadequate reduction	25	20.3	1.6
Medial migration of femoral shaft with penetration of nail into or across hip joint	21	17.0	1.4
Delayed union (and occasionally breaking of the nail)	15	12.1	1.0

FIG. 11-A

FIG. 11-B

This case illustrates the authors' concept of a satisfactory placement of the nail. Of particular importance is the length of the nail which in the roentgenograms is seen to reach the center of the head. It is of equal importance that the shaft of the nail stay within the cortex of the neck of the femur.

shaft must be maintained parallel during insertion. If reduction is complete, this makes for easy insertion of the nail and will prevent any bending force necessary to approximate the plate to the shaft. If the mallet is required for more than the last three-quarters to one-half inch, something is wrong, and in all probability the nail is penetrating the cortex of the neck. Careful reorientation may correct this defect or, if this is unsatisfactory, roentgenograms will demonstrate the difficulty. Multiple insertions of the nail should be avoided at all costs, for they constitute one of the chief causes of disruption of the reduction. With experience, a single set of roentgenograms is all that is necessary. The ideal position for the nail is in the lower half of the neck and head in the anteroposterior view and in the center in the lateral view (Figs. 11-A and 11-B).

In some cases, fixing the lesser trochanter with a long screw or wire increases the degree of stabilization and improves the postoperative comfort. In trochanteric fractures in which the lesser trochanter has remained attached to the proximal fragment, reduction is difficult unless it is done with the extremity in more flexion. Insertion of the nail in this position is the surest way to maintain reduction during this phase of the procedure.

If there is a firm impaction of the cortical bone at the base of the neck into the cancellous bone of the greater trochanter, this spontaneously produced stabilization should not be disturbed, but the fracture should be transfixed in this position even if some degree of coxa vara persists.

REFERENCES

1. BOYD, H. B., and GRIFFIN, L. L.: Classification and Treatment of Trochanteric Fractures. Arch. Surg., **58**: 853–866, 1949.
2. CLEVELAND, MATHER; BOSWORTH, D. M.; and THOMPSON, F. R.: Intertrochanteric Fractures of the Femur. Survey of Treatment in Traction and by Internal Fixation. J. Bone and Joint Surg., **29**: 1049–1067, Oct. 1947.
3. NEUFELD, A. J.; MULFORD, T. M.; and STEGGALL, CLAIR: Intertrochanteric Fractures of the Hip. Western J. Surg., **58**: 219–220, 1950.
4. TAYLOR, G. M.; NEUFELD, A. J.; and JANZEN, J.: Internal Fixation for Intertrochanteric Fractures. J. Bone and Joint Surg., **26**: 707–712, Oct. 1944.

HOMOGENOUS BONE GRAFTS IN SPINE FUSIONS FOR TUBERCULOSIS

BY SIDNEY N. EICHENHOLTZ, M.D., AND VICTOR MAYER, M.D., BRONX, NEW YORK

From the Orthopaedic Service, Veterans Administration Hospital, Bronx

The establishment of the bone bank has created a source of bone critically needed by many patients who require extensive fusions for tuberculosis of the spine. Autogenous sources frequently contain an insufficient quantity of grafting material for these needs. Such was the case in the series here reported. The series was started in September 1947 and followed continuously for five years. The success or failure of fusion has been determined by clinical and roentgenographic examination and by actual surgical exposure of the fusion area. In planning surgical treatment, one must resolve such questions as:

1. Should the fusion be done unilaterally or bilaterally?

2. Should the fusion extend over a long segment of the spine, or should it be confined to several short segments, with the procedure being done in stages?

3. Should the fusion cover only the site of bone disease, or should it extend over the entire area of the abscess?

We have attempted to answer these and similar questions from our experience with this series.

The primary aim of treatment of tuberculosis of the spine is to obtain a surgical fusion of the posterior elements. Repeated surgical repair of pseudarthrosis is frequently required, but we are convinced that the end result justifies this.

Sixty-eight patients are included in the series which is the basis for this report. Since all the patients were veterans of World War I or World War II, the ages of the patients varied between twenty and seventy-five, 75 per cent. being between twenty and forty. In Chart I is shown the distribution according to age. Two patients died before adequate evaluation was possible, and one patient was too recently operated upon to be included in the end-result study. Therefore, a total of sixty-five patients was observed for periods ranging from nine months to five years.

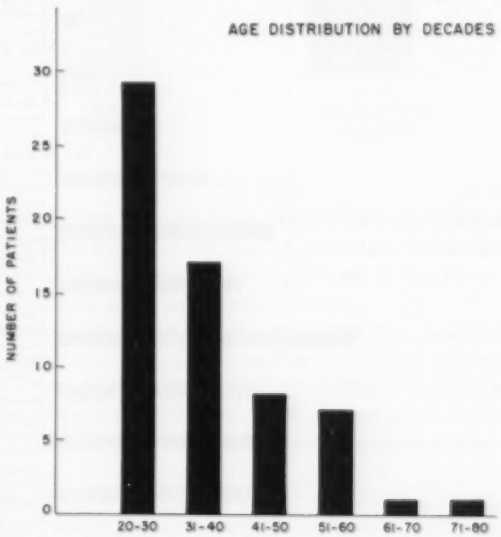
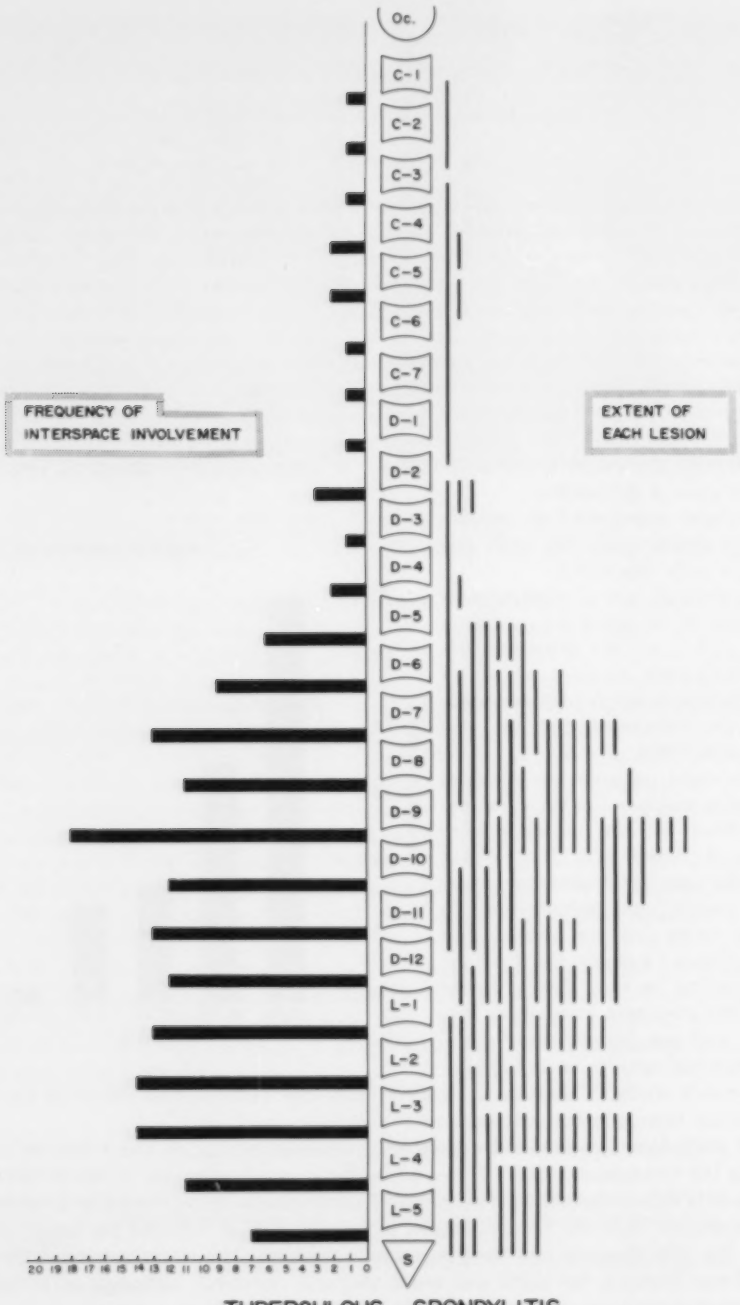


CHART I

The sixty-five patients had eighty-four separate lesions of the vertebral column, involving 169 interspaces. Chart II is a pictographic representation of the extent of each lesion; in it is demonstrated the frequency of involvement of individual interspaces. It is readily apparent that the preponderance of lesions (153 of 169—90 per cent.) occurred between the fifth thoracic and the first sacral vertebrae. The interspace most frequently involved was between the ninth and tenth thoracic vertebrae, although all of the intervening interspaces were well represented.

Twenty-five orthopaedic surgeons, including members of both the Attending Staff and the Resident Staff, performed a total of ninety-eight primary operations and ninety-



TUBERCULOUS SPONDYLITIS

SITE OF LESION

CHART II

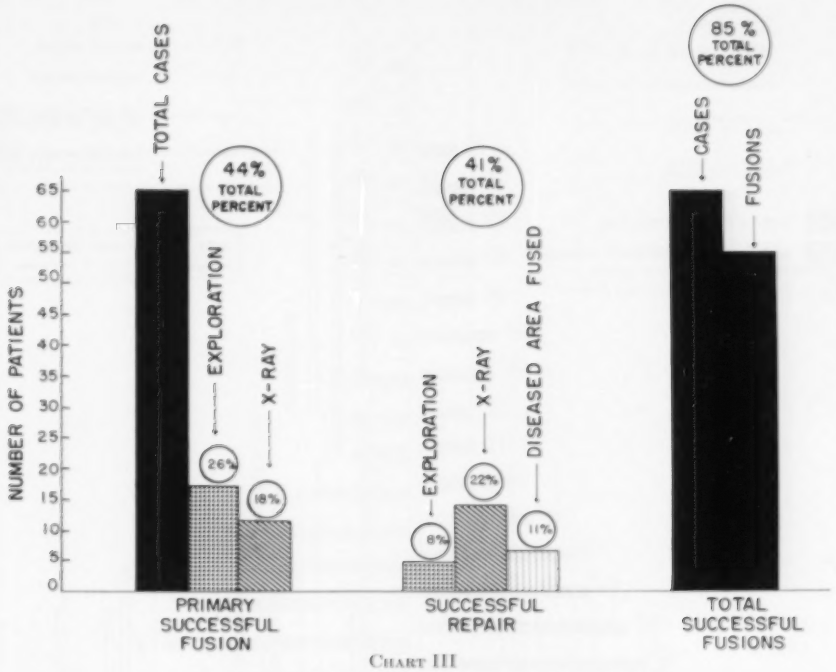


CHART III

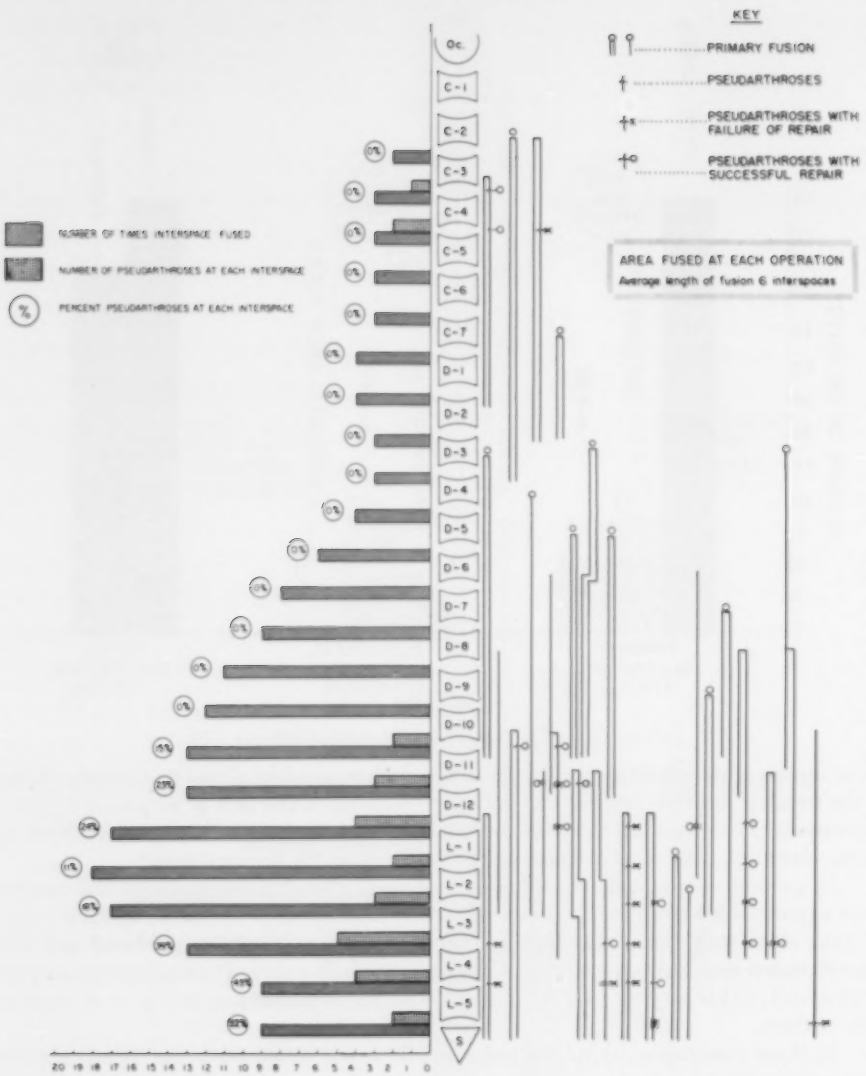
Patients successfully operated upon, bank bone being used.

three repairs of pseudarthroses. This seemingly high proportion of repair of pseudarthroses is the result of multiple attempts to obtain solid fusion in the face of persistent failure at a particular interspace in relatively few patients. Pseudarthrosis developed in thirty-six of the sixty-five patients considered in this study after the primary fusion.

In general, a modified Hibbs fusion was used. The spinous processes and laminae were exposed adequately, and decortication was accomplished by the meticulous raising of bone chips with Cobb spine gauges. These chips were carefully interlaced and were interdigitated over the entire length of the proposed fusion area. Homogenous bone grafts were added, either as long thin cortical strips or as cancellous fragments, or a combination of these.

In those patients in whom the lesion involved few spinal segments, bilateral fusion was performed. In patients with more extensive lesions, when the operative risk was deemed considerable, the procedure was carried out in two or more unilateral stages. The decision as to the extent of the procedure was based primarily upon an evaluation of the patient generally, rather than upon such individual factors as the lymphocyte-monocyte ratio, the sedimentation rate, and the temperature. Since the preoperative study invariably included pulmonary, genito-urinary, and skeletal surveys, surgical judgment as to operative risk was quite accurate. Thus, with these considerations in mind, if a patient was judged suitable for a bilateral fusion performed in one stage, this was attempted; if, on the other hand, extensive lesions or multiple small lesions existed, fusion in stages was considered the procedure of choice. It was noted that, of sixty-five patients, thirty-eight (58.5 per cent.) had bilateral fusions and twenty-seven (41.5 per cent.) had unilateral fusions performed in stages.

For the purposes of evaluation, a primary procedure was considered one in which bank bone was initially applied to the posterior elements of the spine overlying the site

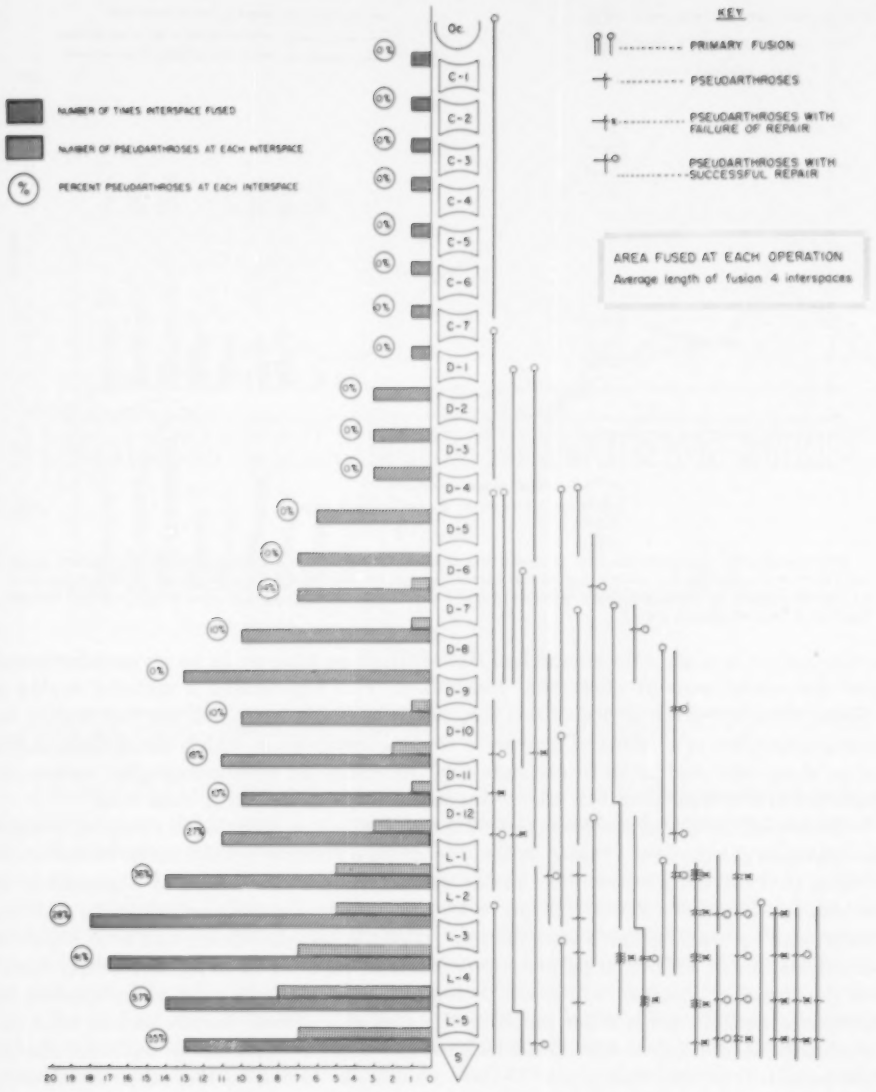


TUBERCULOUS SPONDYLITIS
Unilateral Fusions with Bank Bone

CHART IV

Each line represents the extent of each unilateral fusion. When two or more lines are bridged, they represent the stages of unilateral fusions in an individual patient.

of disease in whole or in part. An exploratory procedure consisted in the exposure of an area previously operated upon in order to determine the solidity of fusion. The earliest exploration was done three and a half months and the latest was done ten months after the primary procedure. In some patients in whom the second stage of a unilateral procedure was undertaken one month after the initial stage, it was noted that no evidence of gross motion could be elicited in the area previously operated upon. In these instances, complete exposure of the opposite surfaces of the spinous processes and laminae previously



TUBERCULOUS SPONDYLITIS
Bilateral Fusions with Bank Bone

CHART V

Each line represents the extent of an individual fusion procedure.

operated upon was not attempted, nor was solid fusion invariably found at this short interval. Nevertheless, it is significant that, in such a short time, some of the patients showed gross solidity of the unilateral fusion. In all patients, however, despite this apparent fusion at one month, the second stage of the procedure was completed. One hundred and one exploratory operations were performed in order to determine the degree of solidity of the fusion. The value of this exploratory procedure was clearly proved. When fusion was successful and no other focus of tuberculosis existed, the patient could be discharged

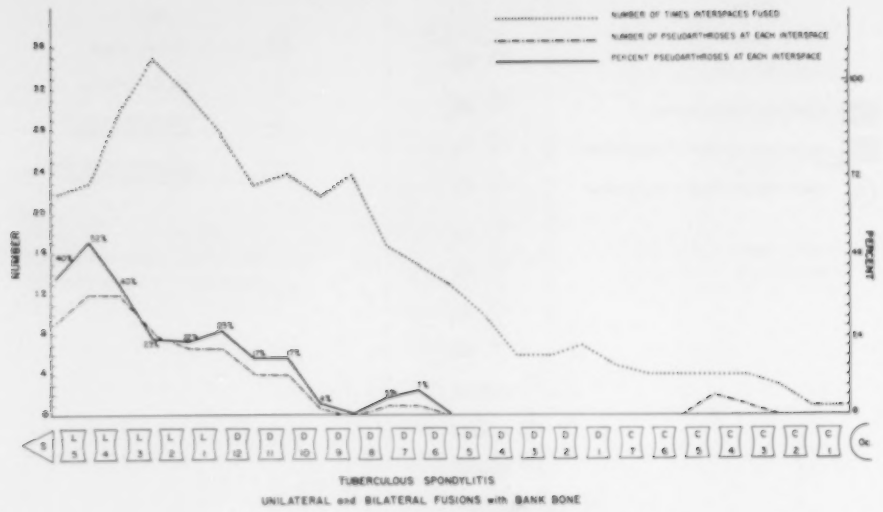


CHART VI

Any parallelism between the line representing the number of times an interspace was operated upon and that representing the percentage of pseudarthroses at an interspace is misleading. If the proportion of the incidence of pseudarthrosis were to remain constant, the percentage line would extend across the chart at a constant level.

to out-patient care after the wound had healed. In those patients in whom pseudarthroses were discovered, prompt repair was undertaken. This represented a material saving of hospital days, since the period of bed rest would have been longer if one had waited for roentgenographic evaluation. There were several instances in which the defects in the fusion mass were so fine as to preclude their detection by roentgenographic means. At exploration, any pseudarthrosis which was found was repaired with bank bone.

Following the initial operation a satisfactory fusion was obtained in a total of twenty-nine patients (44 per cent.); these patients required no further intervention. In seventeen of these patients (26 per cent.) the fusion was determined to be solid by exploration. In an additional twelve patients (18 per cent.) the fusion was determined to be solid by clinical and roentgenographic examination. After the pseudarthroses had been repaired, the defects in five additional patients were found at exploration to be successfully fused; and the fusion in fourteen additional patients was found to be solid as determined by roentgenograms. In seven other patients, the area of vertebral disease and at least one vertebra above and below were found to be solidly fused at exploration; but a pseudarthrosis persisted beyond this point. If these results are added to the other satisfactory results, 85 per cent. of the patients treated had a surgically satisfactory result from the spine fusion in which bank bone was used. In the remaining ten patients (15 per cent.) a pseudarthrosis was accepted; the patients were carefully followed at frequent intervals (Chart III).

While the average length of unilateral fusion was six interspaces and that of the bilateral fusion was four interspaces, we found that there was no relationship between the incidence of pseudarthrosis and the number of interspaces fused at one procedure. We, therefore, concluded that the area of fusion to be attempted at any one procedure is dependent upon the condition of the patient, the availability of bone, and the skill of the operating surgeon (Charts IV and V).

Further evaluation of our data leads to the conclusion that the vertebral interspaces most frequently involved in a fusion operation were not necessarily the site of the major occurrence of pseudarthrosis. This was true whether the patient had the procedure done

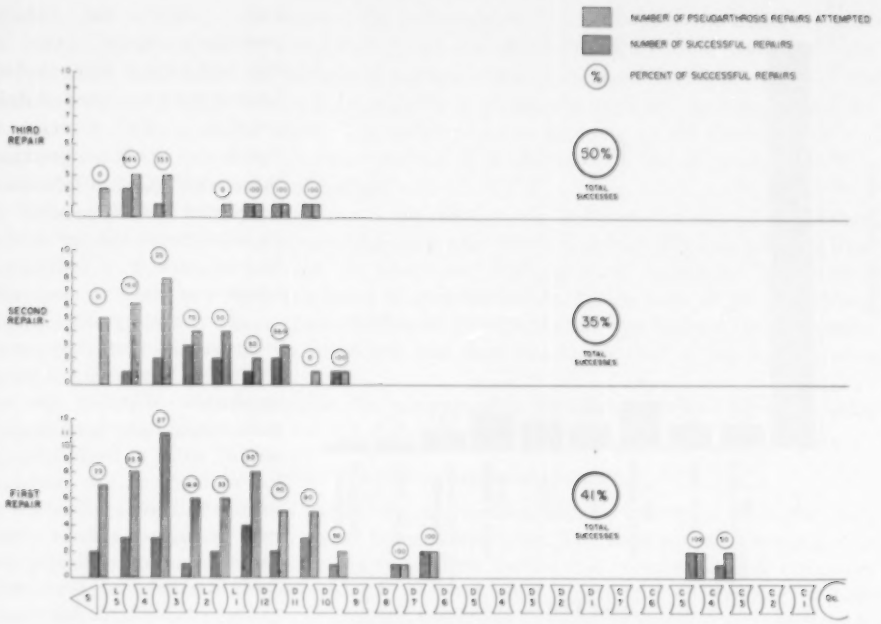


CHART VII

Repair of pseudarthrosis with bank bone.

The percentage in the large circles indicates the degree of success in repairing pseudarthroses, both primary and recurrent. There is no indication that bank bone is less effective in the repair of recurrent psuedarthroses.

in unilateral stages or bilaterally in one stage. In other words, there appeared to be no parallel between the frequency of operation at any particular interspace and the number of pseudarthroses which occurred at that level. It is evident from our results that the peak area of failures occurred between the fourth and fifth lumbar vertebrae (52 per cent.), with two additional high points at the fifth lumbar and first sacral vertebrae and the third and fourth lumbar vertebrae (40 per cent. each). There were no failures in the interspace at the eighth and ninth thoracic vertebrae, despite the great number of operations done at this level. Chart VI illustrates these results. Thus the conclusion drawn more recently that the highest rate of failure of fusion occurs in the lowest three lumbar interspaces, which is undoubtedly due to a mechanical factor rather than to intrinsic disease, is confirmed. The maximum range of motion in the lumbar spine occurs here. The highest percentage of pseudarthrosis, whether the fusion was done unilaterally or bilaterally, occurred in the fourth lumbar interspace. The lowest percentage occurred at the eighth thoracic interspace (Chart VI).

ANALYSIS OF RESULTS FROM REPAIR OF PSEUDARTHROSIS

Consideration of the merit of bank bone for the repair of pseudarthrosis prompted the following analysis of our results. Failure of fusion in sixty-six interspaces was repaired with bank bone. Twenty-seven successful repairs resulted (41 per cent.). At this point, failure of fusion at five interspaces was accepted for a variety of reasons, for example poor anaesthetic risk, poor general condition, patient's refusal of further surgery, or other complicating factors.

A second attempt at repair was made on the thirty-four remaining pseudarthroses. Following this second attempt, solid fusion was achieved at twelve interspaces (35 per

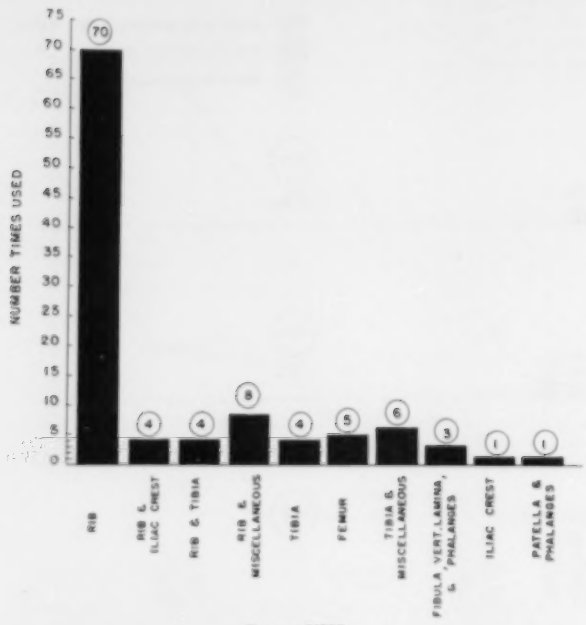


CHART VIII

The anatomical source of bank bone was varied. As demonstrated in this chart, rib bone was used more often than any other type.

cent.). Again, for reasons previously stated, ten of the remaining twenty-two failures were accepted. Subsequently, a third attempt at repair was made on pseudarthroses at twelve interspaces. Successful fusion resulted at six interspaces (50 per cent.). In one patient, a fourth attempt was made to no avail.

In summary, the results indicate that bank bone may be used in the repair of pseudarthrosis. Whether the repairs would have been as successful with a freshening of the surfaces of the pseudarthrosis and the application of local autogenous bone chips and slivers created during the operation has not been definitely established. We have included as failures fifteen pseudarthroses since medical reasons precluded any further operative intervention. Despite this, we were able to achieve a rate of successful repair of 69 per cent. after the third attempt in which bank bone was used. In all fairness in the evaluation of these statistics, it should be borne in mind that in fifteen pseudarthroses further attempts at repair were not made. If these are excluded from the computation, a successful repair in 88 per cent. was obtained. It is of interest to note that in the ten instances of interspace pseudarthrosis occurring after use of fresh autogenous bone in primary fusion (these cases are not included in the previous analysis), five repairs were successful at the first attempt in which homogenous bone was used. A second attempt at repair was made on four of the five failures. In three of these fusion was obtained and at the level where there is the greatest expectancy of failure. Thus eight of the original ten pseudarthroses which occurred following the use of autogenous bone were successfully repaired with bank bone.

When the frequency of failure of pseudarthrosis repair is subjected to analysis with relation to the interspace level, it becomes readily apparent that in the interspaces between the third lumbar and the first sacral vertebrae one can anticipate the poorest results. In a small series of repairs of pseudarthrosis performed with fresh autogenous bone, equally poor results were apparent at these levels.

FACTORS AFFECTING THE INCIDENCE OF PSEUDARTHROSIS

Length of fusion: As demonstrated in Charts IV and V, in which the number and extent of unilateral and bilateral fusions are shown, it is readily evident that the length of the area fused has no direct relationship to the incidence of pseudarthrosis. There were several patients in whom as many as ten and eleven interspaces were operated upon unilaterally without failure of fusion at any level; while with the same unilateral approach, multiple pseudarthroses developed in shorter operative areas of four and five interspaces. This was true also in bilateral procedures.

Unilateral or bilateral operation: Our results indicate that the selection of the unilateral

operation or the bilateral operation as the procedure of choice should not be based on medical indications alone, inasmuch as this choice did affect the incidence of pseudarthrosis. It was noted that, when the unilateral operation was performed, in 90 per cent. of the patients successful fusion resulted. In patients in whom the bilateral operation was done, 83 per cent. had successful fusion. The difference was apparent in the lumbar area and most evident in the lowest two lumbar interspaces. At these levels, the unilateral procedure resulted in a lower percentage of failure.

Site of disease: Our analysis shows no relationship between the site of the disease and the interspace where the pseudarthrosis is most likely to occur. For example, the peak disease area was located between the ninth and tenth thoracic vertebrae. In this zone there was only a 4 per cent. incidence of pseudarthrosis. In the area of the fourth and fifth lumbar vertebrae where the incidence of pseudarthrosis was highest (52 per cent.), the frequency of disease involvement was less than two-thirds that of the thoracic area (compare Charts II and VI).

Age of patients: We found that the occurrence of pseudarthrosis had no relationship to the age of the patients.

POSTOPERATIVE COMPLICATIONS

The discussion of the postoperative complications will be restricted to those which can be related specifically to the use of homogenous bone. The most common complication was superficial serous drainage lasting up to three weeks; this occurred on five occasions. Gross evidence of infection was present in four patients, in all of whom there was drainage some time prior to surgery. In one patient, there was a wound separation and subsequent drainage from which tubercle bacilli were isolated. Two deaths occurred from tuberculous meningitis—one on the ninth postoperative day and the other in the ninth postoperative month.

The safety of the bank bone is thus demonstrated; in five patients in whom the primary procedure was done, superficial drainage with negative culture developed. This responded to treatment in three weeks or less. The remaining seven complications obviously cannot be attributed to the use of bank bone.

VARIETY OF HOMOGENOUS BONE USED

In the overwhelming majority of patients, rib was used for fusion; it was used in seventy procedures. A combination of rib and iliac crest was used in four procedures; a combination of rib and tibia was used in four. Rib with such miscellaneous bone as clavicle, patella, phalanx, femur, fibula, radius, or metacarpal was used in eight patients. Tibia alone was used in four; femur alone was used in five; a combination of tibia and femur was used in six; a combination of fibula, laminae of the spine, and phalanges in three; iliac crest alone was used in one; a combination of patella and phalanges in one (Chart VIII).

In our patients the incidence of pseudarthrosis was not related to the anatomical source of the bank bone. However, it should be pointed out that bank bone in general rarely consists of much cancellous bone. In contradistinction to this, autogenous bone for use in spine fusion is usually obtained from a source rich in cancellous bone. We have accepted the tenet that cancellous bone is superior to cortical bone for use in the Hibbs spine fusion. It is apparent that, in a comparison of the value of homogenous and autogenous bone, the source of the bone in terms of its cancellous content must be considered before an adequate evaluation can be made. Accordingly, we have made no such comparison. In our series, autogenous cancellous bone was not available from readily accessible sources in adequate amounts, because of previous operations. We used cortical and cancellous bone as available and invariably in mixtures; no accurate evaluation, therefore, can be made.

SUMMARY

1. Sixty-eight successive patients with tuberculous spondylitis were subjected to fusion procedures, homogenous bank bone being used.

2. There were 169 vertebral interspaces involved; 90 per cent. were between the fifth thoracic and the fifth lumbar vertebrae.

3. Exploratory operations were done between three and a half and ten months after the previous procedure in 101 cases.

4. The extent of fusion to be attempted at any one procedure is dependent upon the condition of the patient, the availability of bone, and the skill of the operating surgeon. The goal for which we aim is solid fusion of all vertebral bodies involved in the abscess.

5. In 85 per cent. of the patients, final successful fusion, after repair of pseudarthrosis with bank bone, resulted. In 44 per cent. of these, successful fusion resulted after the primary procedure.

6. There was no relationship between the area most frequently diseased and the site most susceptible to pseudarthrosis.

7. The incidence of pseudarthrosis was greatest in the last three lumbar interspaces. In contrast to this, there was not a single instance of pseudarthrosis involving the interspace between the eighth and ninth thoracic vertebrae in twenty-four operations at this level.

8. Bank bone may be used in the repair of pseudarthrosis whether autogenous or homogenous bone was used in the primary fusion procedure. We believe cancellous bone, either autogenous (if available) or homogenous, is desirable.

9. Postoperative complications were relatively few and did not appear to be caused by the use of bank bone.

DISCUSSION

The Place of Nerve-Grafting in Orthopaedic Surgery

(Continued from page 305)

the ring finger to the radial side of the index finger in the presence of a defect of the median nerve. Slides were also shown of a patient in whom a thumb reconstruction had been performed. The index ray had been transferred to the thumb, with normal sensation left undisturbed. The main feature in the Littler-Hilgenfeldt-Gosset methods for thumb reconstruction is transfer of sensation.]

I feel strongly that the nerve-graft procedure, elaborated by the work of Mr. Seddon and his group, in which Mr. Brooks has a prominent place, is of great aid for restoration of motor power. It can help to restore protective sensation. This is very important and may be enough for unskilled heavy work.

Mr. Brooks (closing): I would like to thank my two discussors very much for their comments. Dr. Woodhall has certainly brought out the seamy side of the picture, but in our experience it is not quite so dismal as all that. With regard to Dr. Moberg, it is quite true that transfer of normal skin is one means of overcoming a loss of sensibility, but the patients in whom salvage is attempted by nerve-grafting are those very severely injured in whom such methods are often not possible. I still feel that in these severely injured patients, nerve-grafting is the most satisfactory method that we have at present for achieving recovery of protective sensibility.

STUDIES ON FRACTURE HEALING

BY HANS H. BOHR, M.D., COPENHAGEN, DENMARK

From the Institute for Theoretical Physics, University of Copenhagen, Copenhagen

In a previous paper, the author, in collaboration with Sørensen, published the results of experiments in which the uptake of radio-active phosphorus and calcium in the fractured bones of rats was determined quantitatively. The experiments showed an increase in the radio-activity of the fractured bone as compared with that in the contralateral intact bone; this finding is in conformity with the results obtained by other investigators. The difference was plainly detectable one week after fracturing, and it increased with the healing processes in each animal until the third or fourth week after fracturing. It was also shown that the epiphysis of the contiguous bone took part in the increased activity, although to a lesser degree. On the other hand, no increased activity was observed in the skeleton as a whole.

Several investigations [3,15,19] of the uptake of radio-active phosphorus and calcium in fractured bones have been published since the appearance of our paper. Through these investigations, the results given in the previous paper have been confirmed, and new information regarding healing processes has been added. Some of the problems raised will be dealt with later in the present paper.

The purpose of the present study is to provide further material in an attempt to elucidate the complex phenomenon of fracture healing. Two experiments have been carried out.

EXPERIMENTS

The first experiment was done on forty-nine mature white rats, weighing about 200 grams each. The animals were divided into seven groups, each containing five experimental animals and two control animals. The right femur in all of the experimental animals was broken, as far as possible, in the middle of the diaphysis, under ether anaesthesia. In the first group one week after fracturing, two microcuries of radio-active phosphorus was injected intraperitoneally as an isotonic solution of phosphate in saline. Five days later, the animals were sacrificed, and both femora and tibiae were cleaned by dissection of the attached muscles. The site of the fracture was studied macroscopically in respect to healing; the bones were burnt to white ash in an oven at 800 degrees centigrade in two hours. After incineration, the bones kept their anatomical shape, but the epiphysis was detached at the epiphyseal line and, by careful handling, could be separated from the diaphysis. The diaphysis of each fractured femur was divided into two parts, *A* and *B*, of which *A* included the site of fracture and about five millimeters on each side and *B* comprised the remnants of the diaphysis and the metaphysis. The contralateral (left) femora were divided in the same way, while the tibiae were only separated into diaphysis and proximal epiphysis. Each part was pulverized separately, was placed *in toto* in aluminum dishes, was weighed with an accuracy of $\pm$ 1 per cent., and was measured for radio-activity with Geiger-Müller counters. The ashed bones were kept in exsiccators until they were weighed, in order to avoid uptake of humidity and carbon dioxide from the air.

In the animals in the second group, injection with two microcuries of radio-active phosphorus was done two weeks after fracturing; in the animals in the third group injection of radio-active phosphorus was done three weeks after fracturing, and so on. (In Group 6, however, the animals were given only one microcurie of P^{32}.) Apart from this the bones were treated exactly as were the bones in the first group.

TABLE I

RADIO-ACTIVITY PER TEN MILLIGRAMS OF BONE ASH*

Weeks after fracture	1		2		3		4		5		6		7	
No. of animals														
Experimental	5		5		4		5		5		5		4	
Control	2		2		2		2		2		1		2	
	Rt.	Left	Rt.	Left	Rt.	Left	Rt.	Left	Rt.	Left	Rt.	Left	Rt.	Left
Femoral diaphysis (*A*)**														
Experimental	268	169	185	75	123	96	179	56	90	45	41.2	12.4	233	118
Control	63	62	73	72	59	66	52	51	48	48	19.9	23.3	78	77
Femoral diaphysis (*B*)***														
Experimental	195	174	261	166	114	90	165	131	143	112	31.5	28.1	214	199
Control	157	150	201	194	125	143	116	120	148	130	31.3	33.4	214	200
Femoral epiphysis														
Experimental	200	169	193	140	170	95	141	115	106	93	25.6	24.5	202	173
Control	115	109	135	141	95	100	92	97	111	110	33.1	33.1	155	161
Tibial diaphysis														
Experimental	124	144	122	123	89	79	100	90	84	80	19.4	18.2	143	128
Control	124	122	128	126	100	101	93	100	72	68	20.8	18.8	143	134
Tibial epiphysis														
Experimental	212	182	210	147	151	103	143	122	106	97	23.5	24.2	211	194
Control	150	147	158	155	101	103	98	99	107	101	27.6	31.0	170	164

* The figures indicate counts per minute per ten milligrams of the bones of the right and left sides in each group.

** Diaphysis *A* comprises the site of the fracture and the five millimeters on each side.

*** Diaphysis *B* comprises the rest of the diaphysis and the metaphysis.

In another experiment, the measurements of radio-activity and weight of the bones were made up to one year after fracture. Further confirmation of previous results was obtained. The experiment was done on seventy rats of the same strain and weight as those in the previous experiments. The animals were divided into seven groups, each of which included eight experimental animals and two controls. Of the experimental animals, the right femur was fractured in four and the left femur was fractured in four. In the first group, one microcurie of radio-active phosphorus was injected intraperitoneally five weeks after fracturing, and the animals were sacrificed five days later. Roentgenograms were made of the fractured bones, and, after dissection, they were ashed in the same manner as were the bones in the first experiment. The epiphysis was separated from the diaphysis, and each part was weighed with an accuracy of ± 1 per cent. The epiphyses and diaphyses of the different bones were then pulverized and were placed in dishes for the measuring of the radio-activity. In some cases, radio-autograms were made by placing the bones after ashing on x-ray films with emulsion especially adapted for use without an intensifying screen for seventy-two hours. During exposure the bones were kept in place on the film by the pressure of a plastic bag partly filled with water. The bones of the animals in the other groups were treated similarly except that, in the second group, radio-active phosphorus was injected eight weeks after fracturing and in the remaining groups fifteen, twenty-three, twenty-six, and fifty-two weeks, respectively, after fracturing.

The radio-activity was measured with Geiger-Müller counters placed above and below each sample which had been put in an apparatus similar to that described by Ambrosen and his associates. The background count, which was constantly controlled, varied between twenty-one and twenty-five counts per minute. The bone samples in the

TABLE II

WEIGHT OF THE BONE ASH IN MILLIGRAMS*

Weeks after fracture	1		2		3		4		5		6		7	
No. of animals														
Experimental	5		5		4		5		5		5		4	
Control	2		2		2		2		2		1		2	
	Rt.	Left	Rt.	Left	Rt.	Left	Rt.	Left	Rt.	Left	Rt.	Left	Rt.	Left
Femoral diaphysis (*A*)**														
Experimental	44.0	33.1	60.6	43.3	80.1	62.2	64.2	39.6	57.7	50.2	59.0	50.4	69.2	58.7
Control	32.1	38.0	48.1	42.7	60.2	60.3	35.8	48.7	51.0	47.9	33.9	44.5	66.0	61.3
Femoral diaphysis (*B*)***														
Experimental	49.6	60.9	53.0	63.7	83.0	85.9	75.0	81.3	66.8	64.3	80.5	82.1	69.5	86.2
Control	88.0	82.9	48.7	51.2	92.3	91.1	80.9	79.2	56.3	56.7	82.7	64.8	79.2	86.3
Femoral epiphysis														
Experimental	20.0	26.4	22.1	27.1	29.7	36.5	27.2	30.3	27.0	29.1	30.1	33.7	28.3	35.1
Control	30.4	29.7	28.0	27.2	34.4	33.9	33.8	31.3	27.6	26.6	25.9	25.2	34.9	34.6
Tibial diaphysis														
Experimental	52.4	54.3	61.3	61.1	80.4	81.6	61.8	70.1	60.7	64.2	63.0	71.0	70.0	73.6
Control	58.0	58.6	65.5	71.5	79.9	78.7	77.8	71.6	59.4	59.4	63.1	68.9	82.0	78.4
Tibial epiphysis														
Experimental	10.6	12.4	11.0	12.9	14.5	18.1	13.6	15.1	12.7	14.3	15.4	16.0	13.6	17.0
Control	14.9	15.4	12.7	12.6	16.3	17.8	14.7	15.1	12.9	13.0	12.8	12.7	17.1	17.0

* The figures indicate the mean weight of the bones of the right and left sides in each group.
** Diaphysis *A* comprises the site of the fracture and five millimeters on each side.
*** Diaphysis *B* comprises the rest of the diaphysis and the metaphysis.

TABLE III

DIFFERENCES IN RADIO-ACTIVITY AND WEIGHT OF THE BONE ASH*

Weeks after fracture	1	2	3	4	5	6	7	Control Animals
No. of animals	5	5	4	5	5	5	4	14
Femoral diaphysis (*A*)								
Activity	+109	+170	+145	+185	+112	+222	+125	6
Weight (*A* + *B*)	− 3	0	+ 4	+ 7	0	+ 3	− 5	3
Femoral diaphysis (*B*)								
Activity	+ 27	+ 67	+ 31	+ 42	+ 29	+ 22	+ 8	8
Femoral epiphysis								
Activity	+ 25	+ 39	+ 80	+ 25	+ 7	+ 6	+ 16	4
Weight	− 23	− 18	− 18	− 10	− 13	− 1	− 20	3
Tibial diaphysis								
Activity	− 6	− 2	+ 12	+ 11	+ 7	+ 5	+ 12	6
Weight	− 7	− 2	− 3	− 11	− 8	− 6	− 8	4
Tibial epiphysis								
Activity	+ 24	+ 43	+ 48	+ 18	+ 7	− 3	+ 8	6
Weight	− 21	− 14	− 20	− 10	− 13	− 1	− 20	5

* The figures indicate the mean difference between the bones of the right and the left sides in each group, expressed in percentage of the figures of the bones of the left side.

TABLE IV

RADIO-ACTIVITY AND WEIGHT OF THE BONE ASH ACCORDING TO THE DEGREE OF FRACTURE HEALING IN THE FIRST EXPERIMENT*

Degree of healing	Good		Poor		Bad	
	Radio-activity	Weight	Radio-activity	Weight	Radio-activity	Weight
Femoral diaphysis (*A*)		*A* + *B*		*A* + *B*		*A* + *B*
3 weeks	+141(3)	+10(3)	(0)	(0)	+159(1)	+ 1(1)
4 weeks	+169(3)	+12(3)	+204(1)	+ 7(1)	+214(1)	− 4(1)
5 weeks	+ 53(2)	+ 9(2)	+150(1)	− 1(1)	+153(2)	− 9(2)
6 weeks	+261(3)	+11(3)	+143(1)	+ 8(1)	+183(1)	−13(1)
7 weeks	(0)	(0)	+174(1)	+ 4(1)	+108(3)	−14(3)
Mean	+165(11)	+11(11)	+168(4)	+ 5(4)	+148(8)	−10(8)
Femoral diaphysis (*B*)						
3 weeks	+ 80(3)		(0)		+ 83(1)	
4 weeks	+ 56(3)		+ 94(1)		+106(1)	
5 weeks	+ 26(2)		+ 66(1)		+ 74(2)	
6 weeks	+ 82(3)		+ 47(1)		+144(1)	
7 weeks	(0)		+ 37(1)		+ 43(3)	
Mean	+ 64(11)		+ 61(4)		+ 80(8)	
Femoral epiphysis						
3 weeks	+ 81(3)	−15(3)	(0)	(0)	+ 69(1)	−25(1)
4 weeks	+ 16(3)	− 6(3)	+ 26(1)	−14(1)	+ 49(1)	−18(1)
5 weeks	− 2(2)	+ 2(2)	+ 14(1)	−21(1)	+ 14(2)	−28(2)
6 weeks	+ 6(3)	− 2(3)	− 1(1)	− 2(1)	+ 19(1)	−16(1)
7 weeks	(0)	(0)	+ 17(1)	−10(1)	+ 23(3)	−21(3)
Mean	+ 28(11)	− 6(11)	+ 14(4)	−12(4)	+ 29(8)	−22(8)
Tibial epiphysis						
3 weeks	+ 46(3)	−14(3)	(0)	(0)	+ 52(1)	−26(1)
4 weeks	+ 14(3)	− 4(3)	+ 21(1)	−22(1)	+ 27(1)	−15(1)
5 weeks	− 3(2)	+ 1(2)	+ 11(1)	−18(1)	+ 16(2)	−24(2)
6 weeks	− 6(3)	− 3(3)	− 3(1)	+19(1)	+ 9(1)	−18(1)
7 weeks	(0)	(0)	+ 1(1)	−12(1)	+ 6(3)	−22(3)
Mean	+ 14(11)	− 6(11)	+ 8(4)	−8(4)	+ 17(8)	−22(8)

* The figures indicate the mean difference between the bones of the right and the left sides, expressed in percentage of the figures of the bones of the left side. The number of animals in each group is given in parentheses.

first experiment showed activity above 100 counts per minute, while in the second experiment activity was above fifty counts per minute. The weight of the bone samples which were compared differed so little that the corrections made for absorption were less than 1 per cent.[10]; the measurements of the radio-activity were carried out with an accuracy of ±1.5 per cent.

RESULTS

The results of the measurements of the radio-activity in the first experiment are shown in Tables I and II. It is seen that there was a marked increase in the activity of the fractured bones in each group, as regards both the diaphysis and the epiphysis. In the proximal epiphysis of the right tibia the increase was less but, in the mean, statistically significant when compared with the increase in the control figures. In accordance with the observation made by Wilkinson and Leblond, the left femoral diaphyses of

TABLE V

RADIO-ACTIVITY AND WEIGHT OF THE BONE ASH ACCORDING TO THE HEALING OF THE FRACTURES IN THE SECOND EXPERIMENT*

Clinical healing	Good		Poor		Bad		Controls	
	Radio-activity	Weight	Radio-activity	Weight	Radio-activity	Weight	Radio-activity	Weight
Femoral diaphysis								
5 weeks	+178(1)	+11(1)	+192(1)	− 5(1)	+115(2)	− 1(2)	7(1)	3(1)
8 weeks	+152(2)	+23(2)	(0)	(0)	+ 54(6)	−13(6)	9(2)	3(2)
10 weeks	+ 93(3)	+14(3)	+145(1)	− 1(1)	+102(3)	−11(3)	7(2)	2(2)
15 weeks	+ 34(1)	+17(1)	+122(3)	+15(3)	+ 33(2)	−15(3)	8(3)	2(3)
23 weeks	+ 26(1)	+13(1)	(0)	(0)	+ 33(5)	−13(5)	6(2)	2(2)
26 weeks	+ 50(1)	+11(1)	+ 25(3)	+11(3)	+ 30(3)	−11(3)	5(2)	3(2)
52 weeks	+ 18(1)	+14(1)	+ 10(4)	+ 6(6)	+ 27(5)	−20(8)	5(4)	2(5)
Mean	+ 89(10)	+15(10)	+ 68(12)	+ 8(14)	+ 54(26)	−12(30)	7(16)	2(17)
Femoral epiphysis								
5 weeks	+234(1)	−20(1)	+136(1)	−25(1)	+ 83(2)	−15(2)	7(1)	0(1)
8 weeks	+ 26(2)	− 5(2)	(0)	(0)	+ 32(6)	−16(6)	19(2)	7(2)
10 weeks	+ 25(3)	− 1(3)	+ 40(1)	−11(1)	+ 42(3)	−15(3)	8(2)	1(2)
15 weeks	− 14(1)	− 4(1)	+ 23(3)	−19(3)	+ 12(2)	−19(3)	8(3)	3(3)
23 weeks	+ 28(1)	−12(1)	(0)	(0)	+ 11(5)	−17(5)	4(2)	2(2)
26 weeks	+ 22(1)	+ 3(1)	0(3)	− 3(3)	+ 7(3)	−15(3)	0(2)	7(2)
52 weeks	+ 8(1)	+11(1)	+ 2(2)	− 5(5)	+ 25(5)	−15(7)	6(3)	1(5)
Mean	+ 41(10)	− 6(10)	+ 25(10)	− 9(13)	+ 31(26)	−16(29)	7(15)	3(17)
Tibial epiphysis								
5 weeks	+166(1)	−17(1)	+ 79(1)	−27(1)	+ 64(2)	−13(2)	2(1)	3(1)
8 weeks	+ 12(2)	+ 1(2)	(0)	(0)	+ 31(6)	−11(6)	5(2)	4(2)
10 weeks	+ 21(3)	− 6(3)	+ 10(1)	−16(1)	+ 16(3)	−11(3)	15(2)	6(2)
15 weeks	0(1)	− 7(1)	+ 7(2)	−14(3)	+ 16(2)	−25(3)	14(2)	4(3)
23 weeks	+ 18(1)	− 8(1)	(0)	(0)	+ 8(5)	−11(5)	7(2)	2(2)
26 weeks	− 16(1)	− 3(1)	+ 16(3)	+ 1(3)	+ 16(3)	−18(3)	13(2)	3(2)
52 weeks	(0)	(0)	+ 10(1)	+ 3(3)	+ 16(2)	−16(3)	6(1)	2(3)
Mean	+ 28(9)	− 6(9)	+ 20(8)	− 7(11)	+ 22(23)	−14(25)	19(12)	4(15)
Tibial diaphysis								
5 weeks	+ 29(1)	− 5(1)	+ 1(1)	− 5(1)	+ 11(2)	− 5(2)	1(1)	3(1)
8 weeks	+ 41(2)	0(2)	(0)	(0)	+ 12(6)	− 6(6)	4(2)	4(2)
10 weeks	+ 7(2)	− 3(3)	(0)	− 8(1)	+ 5(2)	− 6(3)	8(1)	2(2)
15 weeks	− 13(1)	+ 1(1)	+ 24(3)	− 5(3)	+ 8(2)	− 4(4)	5(3)	2(3)
23 weeks	+ 26(1)	−20(1)	(0)	(0)	+ 9(5)	− 6(4)	2(2)	1(2)
26 weeks	− 4(1)	+ 1(1)	+ 31(3)	− 1(3)	+ 11(3)	− 7(3)	0(2)	2(2)
52 weeks	(0)	(0)	(0)	− 6(3)	+ 19(2)	−10(3)	3(2)	1(2)
Mean	+ 15(8)	− 4(9)	+ 24(7)	− 4(11)	+ 11(22)	− 6(24)	3(15)	2(14)

* The figures indicate the percentage of difference between the fractured bone and the contralateral intact bone. The number of animals in each group is given in parentheses.

the experimental animals also showed a somewhat higher mean value than that in the control animals.

In Table III, the difference in activity and weight of corresponding bone samples from the right and left sides of the experimental animals has been calculated. It is shown that, while the activity in the site of the fracture increased by 100 to 200 per cent., the activity in the diaphysis (*B*), as well as the epiphysis, of the fractured femur increased only from 25 to 50 per cent. The increase in activity at the site of the fracture

TABLE VI

AMOUNT OF PHOSPHORUS IN DIFFERENT BONE SAMPLES OF RELATIONS OF PHOSPHORUS CONTENT OF BONE ASH*

	Experimental Animals			Control Animals		
	Fractured Bone	Contralateral Bone	Difference**	Right	Left	Difference**
Femoral diaphysis	185	181	4			
	179			185		
	177	177	0	174	176	2
	175	179	2			
Tibial diaphysis	176	174	1	180	181	1
	179					
Femoral epiphyses	196	185	10			
	190	172	2	176		
	172	173	1	177	173	4
	170	180	5			
Tibial epiphysis	185	185	1	184	179	4
		181				
	Mean difference		3	Mean difference		3

* The phosphorus content is determined colorimetrically.
** Percentile difference between the bones of the right and the left side.

was almost the same in the first and the last group. The increase in activity in the diaphysis (*B*) was less from the fourth week after fracturing, and in the epiphyses of the femur and tibia it was less from the third week after fracturing.

With regard to the differences in weight of the bone ash, a considerable loss of weight in the epiphyses of the femur and tibia was observed from the first week after the fracturing. This lost mineral substance, which amounted to about 20 per cent., was gradually replaced. (The reason it is also seen in the last group in this experiment is due to the circumstance that all four animals in this group had poor healing.)

In Table IV, the same material as that in Table III is arranged according to the degree of healing of the fracture evaluated after the third week following the fracturing. Those bones which on dissection showed consolidation are considered to have good healing, and the other bones are considered to have poor or bad healing, depending upon whether the mobility at the fracture was above or below 60 degrees °. The figures show that the increase in activity on the average was the same for bones with good healing as for those with poor or bad healing. As regards weight, it is seen that, while the weight of the epiphyses of the bones with good healing increased from the third week following fracturing, those in bones with poor healing showed a constant loss in weight.

The results of the second experiment are given in Table V. Here figures indicate the percentage of difference in radio-activity and weight between the fractured bone and the contralateral intact bone. In Table V, the results of the measuring of the radio-activity show that the previously described increase in radio-activity in the fractured diaphyses was less marked eight weeks after fracturing, but, nevertheless, it remained distinct until the sixth month. In the epiphyses of the femora and tibiae only a slight increase in radio-activity was seen after the eighth week. As in the previous experiment, the difference in the average figures of the radio-activity between the bones with good and bad healing was not statistically significant, but a significant difference did exist between bones with different degrees of healing as regards their weight.

Fig. 1: Roentgenograms made eight weeks after fracturing. The femur on the left shows good healing, while that in the middle and that on the right show bad healing.

Fig. 2: Roentgenograms made fifteen weeks after fracturing. The femur on the left shows good healing; the femur in the middle shows poor healing; and the femur on the right shows bad healing.

Fig. 3: Roentgenograms made twenty-six weeks after fracturing. The femur on the left shows good healing; the femur in the middle shows poor healing; and the femur on the right shows bad healing.

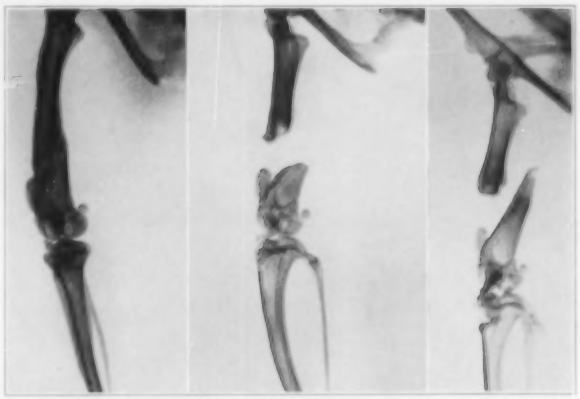


FIG. 1

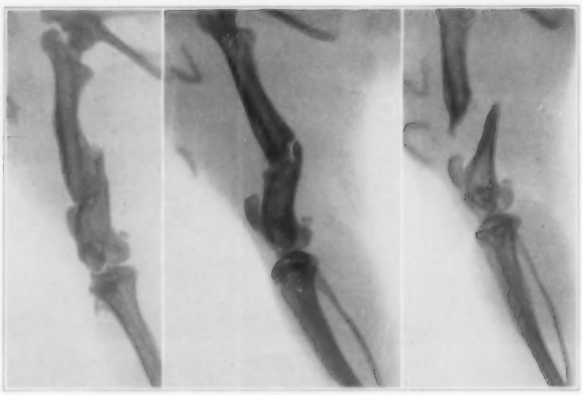


FIG. 2

FIG. 3

The degree of healing as determined through dissection and by means of roentgenograms was in good agreement. Figures 1 through 3 illustrate different degrees of healing at eight, sixteen, and twenty-six weeks after fracturing.

DISCUSSION

Before discussing the results, it is necessary to point out that, although the radio-activity is determined per milligram of bone ash, it also represents the activity per milligram of phosphorus. Table VI shows that the amount of phosphorus in the different samples of bone ash from animals with different degrees of fracture healing only varied within 10 per cent. and that the average difference between the amount of phosphorus in a fractured bone and the contralateral intact bone was only ±3 per cent. An increase in radio-activity of the bone samples above 10 per cent. as compared with the sample from the contralateral bone may, therefore, be regarded as an expression of an increased uptake of radio-active phosphorus per milligram of inactive phosphorus.

It is well known that the uptake of radio-active phosphorus, as well as that of radio-active calcium, may be due, on the one hand, to new-bone formation or, on the other hand, to the processes of exchange, either through the physical replacement of surface

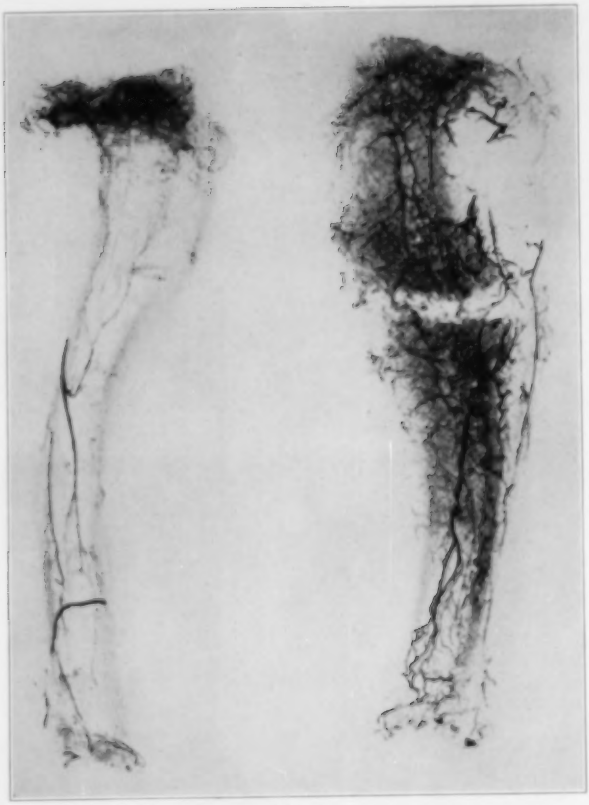


Fig. 4: Hyperaemia five weeks after the fracture of the right tibia of a dog was demonstrated by means of arteriography. (Reproduced by permission from *Lehrbuch der allgemeinen Chirurgie zum Gebrauche für Ärzte und Studierende*, 20. Aufl., 2. Band, S. 66, von Erich Lexer.)

Fig. 5: Radio-autograms made five to eight weeks after fracturing. At the top are the fractured femora; at the bottom are the contralateral intact femora. The epiphyses had previously been removed.

Fig. 4

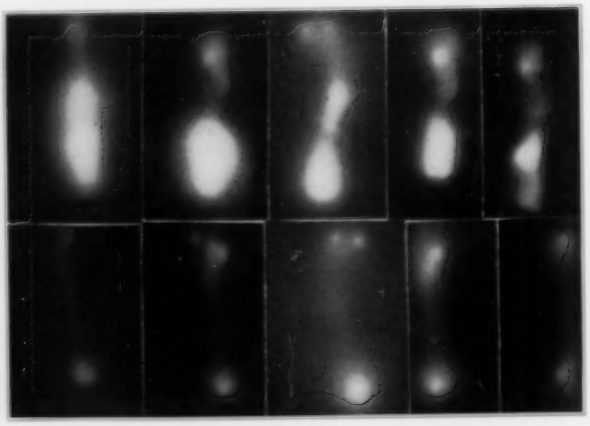


Fig. 5

molecules or through biological recrystallization [10].

In a previous paper, the author in collaboration with Sørensen thought that the exchange processes were the main cause of the increased uptake of radio-active phosphorus found in the fractured bone. Recent investigations by Carlsson and Bauer seem to show, however, that processes of exchange only influence the uptake of radio-active phosphorus and calcium during the first forty-eight hours after the injection of the isotope and that all of the activity accumulated at a later period must be explained by new-bone formation. According to these and other investigations [3,4,6,8], a continuous rebuilding and breaking down occurs in living bone tissue, additional layers being deposited by osteoblasts within the Haversian canals and resorption taking place simultaneously in other parts of the bone.

In the present investigations, the site of the increased uptake of radio-active phosphorus in the fractured bone corresponded to the site of the increased vascularization, which was demonstrated in fractured bones by Lexer. Figure 4 shows that the increased vascularization around the fracture also extends to the rest of the diaphysis, as well as to the epiphyses. Such hyperaemia greatly facilitates the exchange of phosphorus and, at the same time, stimulates new-bone formation. A few radio-autograms of fractured bones compared with the

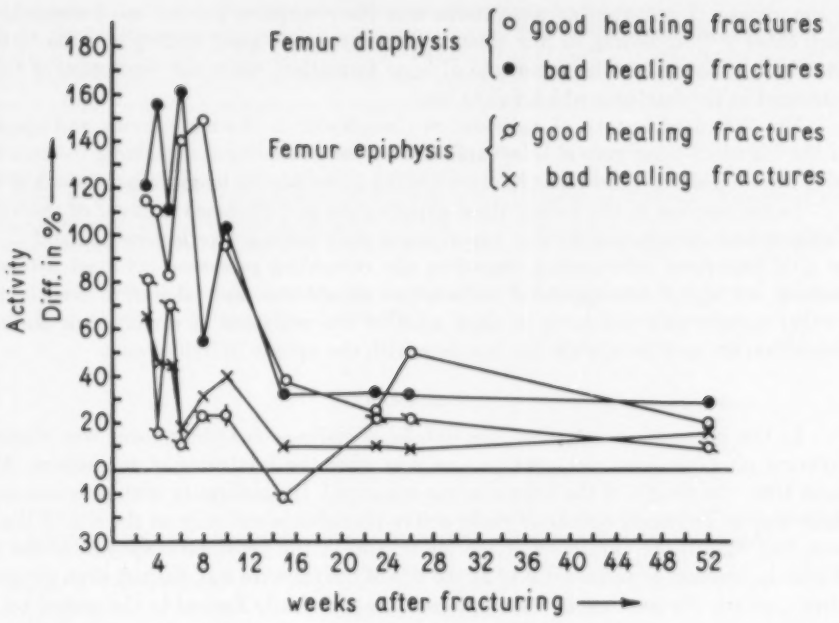


CHART I

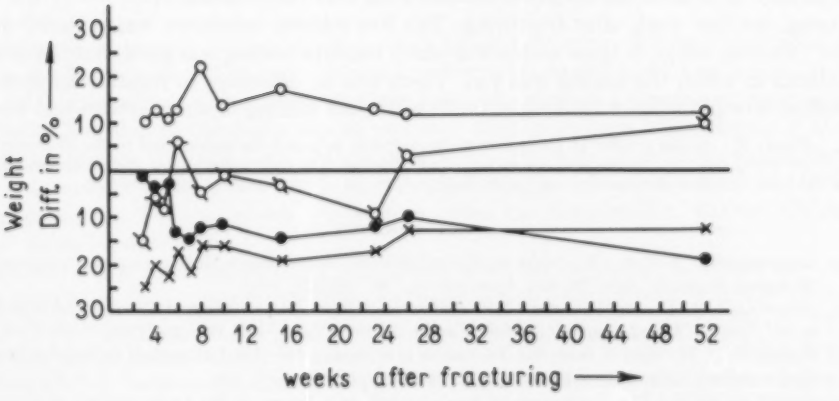


CHART II

contralateral intact bone are shown in Figure 5. Without entering into the details of description of these figures, as the technique of radio-autography used does not make them adequate for quantitative study, I shall only point out the resemblance between these and Figure 4, showing that the distribution of radio-active phosphorus follows the area of the hyperaemia.

While hyperaemia of the fractured bone may be the cause of the increased uptake of radio-active phosphorus, it cannot at the same time explain the loss of weight occurring in the badly healing bones, as mentioned by different authors [12,13,15]. A survey of the results of the measurements of the radio-activity and the weight of the bones has been given in Charts I and II. As has been pointed out before, it is seen that the uptake of radio-active phosphorus is independent of the degree of fracture healing, while there is a decisive difference as regards the weight of the bones. This fact is more easily explained

if the uptake of radio-active phosphorus and the resorption process are independent of each other[3,4,5]. According to this view, the fractures with good healing and the fractures with bad healing show the same rate of bone formation, while the resorption of bone is increased in the fractures which fail to heal.

The increased uptake of radio-active phosphorus in the metaphyses and epiphyses of the fractured bone may also be explained by the processes of rebuilding in accordance with the clinical experience that fracture healing promotes the longitudinal growth of bone.

In the opinion of the author these experiments give evidence in favor of the view of Carlsson and Bauer, and further experiments with radio-active isotopes should be able to give important information regarding the rebuilding processes involved in fracture healing. As regards the uptake of radio-active phosphorus and calcium in dead bone[14,17] further experiments will have to show whether the processes of exchange or additional deposition on apatite crystals can compete with the uptake in living bone.

SUMMARY

In the present investigation, the uptake of radio-active phosphorus was studied at different intervals from one week to one year after the fracturing of rat femora. At the same time, the weight of the bone ash was measured. In conformity with previous results, there was an increased uptake of radio-active phosphorus not only at the site of the fracture, but also in the epiphyses of the femur and in the proximal epiphysis of the tibia. While the increase in radio-activity at the site of the fracture was distinct even six months after fracture, the increase in the epiphyses was practically limited to the period between the first and the eighth week. The weight of the bone ash showed a marked reduction, especially as regards the epiphyses of the femur and the proximal epiphysis of the tibia, during the first week after fracturing. This lost mineral substance was replaced during the following weeks in those animals in which fracture healing was good, but not in those animals in which the healing was bad. There was no difference as regards the uptake of radio-active phosphorus between animals with good healing or animals with bad healing.

NOTE: My thanks are due to Prof. Hevesy for valuable help and discussions and to the Pharmaceutical Laboratories Løven for the ample facilities put at my disposal. The determinations of the phosphorus content of the bone samples were carried out by A. Fuchs, M.S., to whom I express my gratitude.

REFERENCES

1. AMBROSEN, J.; MADSEN, B.; OTTESEN, J.; and ZERAHN, K.: A Geiger-Müller Counter Arrangement for Biological Research. Acta Physiol. Scandinavica, **10**: 195–213, 1945.
2. ARMSTRONG, W. D., and BARNUM, C. P.: Concurrent Use of Radioisotopes of Calcium and Phosphorus in the Study of Metabolism of Calcified Tissues. J. Biol. Chem., **172**: 199–204, 1948.
3. BAUER, G. C. H.: Rate of Bone Salt Formation in a Healing Fracture Determined in Rats by Means of Radiocalcium. Acta Orthop. Scandinavica, **23**: 169–191, 1954.
4. BAUER, G. C. H.: The Importance of Bone Growth as a Factor in the Redistribution of Bone Salt. II. Redistribution of Radio-Active Phosphorus in the Skeleton of Rats. J. Bone and Joint Surg., **36-A**: 381–386, Apr. 1954.
5. BOHR, HANS, and SØRENSEN, A. H.: Study of Fracture Healing by Means of Radio-Active Tracers. J. Bone and Joint Surg., **32-A**: 567–574, July 1950.
6. CARLSSON, ARVID: On the Mechanism of the Skeletal Turnover of Lime Salts. Acta Physiol. Scandinavica, **26**: 200–211, 1952.
7. COMAR, C. L.; LOTZ, W. E.; and BOYD, G. A.: Autoradiographic Studies of Calcium, Phosphorus and Strontium Distribution in the Bones of the Growing Pig. Am. J. Anat., **90**: 113–129, 1952.
8. ENGFELDT, B.; ENGSTRØM, A.; and ZETTERSTRØM, R.: Growth, Structure, and Mode of Reaction of Bone Tissue. Nordisk Med., **49**: 599–601, 1953.
9. ESKELUND, V., and PLUM, C. M.: Experimental Investigations into the Healing of Fractures. Acta Orthop. Scandinavica, **19**: 433–475, 1950.
10. HEVESY, G.: Radioactive Indicators. Their Application in Biochemistry, Animal Physiology, and Pathology. New York, Interscience Publishers, Inc., 1948.
11. LEXER, ERICH: Lehrbuch der allgemeinen Chirurgie zum Gebrauche für Ärzte und Studierende. 20. Aufl., 2. Band, S. 66. Stuttgart, Ferdinand Enke, 1934.

12. DE LORIMER, A. A.: Reflex Hyperemic Deossifications. Bull. Hosp. Joint Dis., **12:** 22–37, 1951.
13. MATTI, H.: Die Knochenbrüche und ihre Behandlung. 2. Aufl., S. 69. Berlin, Julius Springer, 1931.
14. ODELL, R. T.; MUELLER, C. B.; and KEY, J. A.: Effect on Bone Grafts of Radio-Active Isotopes of Phosphorus. J. Bone and Joint Surg., **33-A:** 324–332, Apr. 1951.
15. RUF, F.: Über die Anwendung radioactiver Indicatoren bei der Fracturheilung. Arch. f. Klin. Chir., **267:** 209–212, 1951.
16. SINGER, L., and ARMSTRONG, W. B.: Retention and Turnover of Radiocalcium by the Skeleton of Large Rats. Proc. Soc. Exper. Biol. and Med., **76:** 229–233, 1951.
17. TUCKER, F. R.: The Use of Radioactive Phosphorus in the Diagnosis of Avascular Necrosis of the Femoral Head. J. Bone and Joint Surg., **32-B:** 100–107, Feb. 1950.
18. WATSON-JONES, R.: Fractures and Joint Injuries. Ed. 3, vol. I, p. 6. Edinburgh, E. and S. Livingstone Ltd., 1946.
19. WILKINSON, G. W., and LEBLOND, C. P.: The Deposition of Radiophosphorus in Fractured Bones of Rats. Surg., Gynec., and Obstet., **97:** 143–150, 1953.

ARTHRITIS MUTILANS (*DOIGT, MAIN, PIED EN LORGNETTE*)

BY H. B. EISENSTADT, M.D., PORT ARTHUR, TEXAS, AND G. W. N. EGGERS, M.D., GALVESTON, TEXAS

From the University of Texas School of Medicine, Galveston

Arthritis mutilans is an uncommon destructive joint disorder affecting the hands and fingers, the feet and toes. It was first observed by Pierre Marie and André Léri in a seventy-year-old female patient with extensive polyarthritis who showed a peculiar shortening of the digits. The skin of the digits was thrown into thick transverse folds because it had apparently become too large for the underlying bones. However, the affected fingers were loose and could be easily pulled out to their original length, thus resembling the sections of an opera glass. For this reason, the authors called the disfiguration "the opera-glass hand" (*la main en lorgnette*).

Several years after the original description, Weigeldt published a similar case of opera-glass hand and Stursberg reported two patients with a corresponding change of the feet (*pied en lorgnette*). The latter also suggested the name of polyarthritis mutilans. The total number of patients with this disorder described in the literature is difficult to ascertain[8, 12, 14, 24] because the disease has been confused repeatedly with other entities, especially with the neurotrophic osteopathies[5, 9, 18]. Furthermore, mutilating arthritis has been linked with psoriasis and named arthritis psoriatica [2, 4, 6, 15, 19, 21, 25]. Unfortunately, the latter name has also been used to designate the association of psoriasis with other joint disorders[1, 4, 21]. The majority of the reported cases with opera-glass hand or foot occurred in middle-aged or old persons, especially in females who had been suffering from a generalized joint disease for a period of from ten to fifty years at the time of their clinical examination. These patients exhibited a picture resembling advanced rheumatoid polyarthritis, with or without ankyloses, in addition to the unusual changes of the hands and feet. Only one patient was examined early. However, his joint disorder took a fulminating course and was, therefore, quite advanced at the time of the study [20] (Case 1). On the basis of their findings, most observers concluded that mutilating arthritis is a manifestation of advanced or fulminating rheumatoid arthritis [16].

That such a conclusion is not necessarily correct can be shown by our patient, a seventeen-year-old male, who was observed almost from the beginning of his disease and

FIG. 1

Roentgenograms of the right foot made on August 29, 1950. Note the shape of the fifth metatarsal and excavation of the adjacent first phalanx.

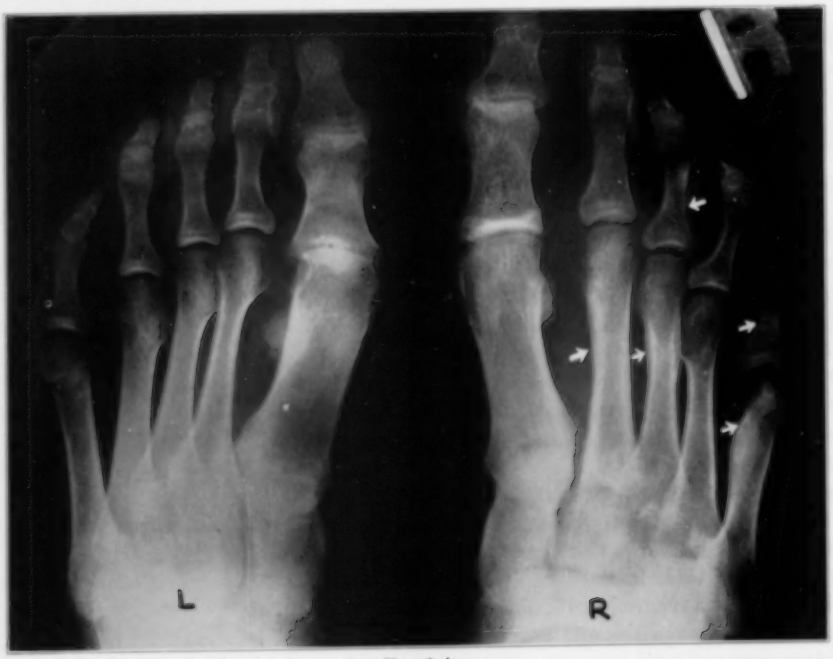


FIG. 2-A

FIG. 2-B

Fig. 2-A: Roentgenograms made on June 21, 1951. Note the periosteal changes in the right metatarsal shafts; the head of the left fifth metatarsal bone appears normal.

Fig. 2-B: Roentgenograms made on the same day, showing irregular new-bone formation in the left heel, punched-out areas in the left first metatarsophalangeal joint, and periosteal changes in the right metatarsal shafts.

in whom, over a period of four years, bilateral opera-glass foot gradually developed without any other joint manifestations. A few months before this report was submitted, however, a temporary arthralgia of the right knee joint indicated the beginning of a further spread of his disorder.

D. Van E. was seen on June 1, 1951, by one of the authors (H. B. E.) because of mild swelling of both feet and pain which made walking difficult. The previous history showed nasal and bronchial allergies which had been present since early childhood, some undetermined abdominal pains of several months' duration in 1943, a tonsillectomy in 1945, and a dislocation of the right elbow joint in 1946. Clinical records and laboratory examinations were available from his hospitalizations in 1943 and 1946. At these admissions, no symptoms arising from his feet or from any joint were present and urinalyses, blood counts, and sedimentation rates gave normal findings with negative Wassermann tests. The patient was an only child. His mother had always enjoyed good health; his father had died of acute pancreatitis in 1940. No member of his family was known to have suffered from a joint or skin disease, and especially no case of psoriasis had ever been noticed.

The foot disorder of our patient had started insidiously on the right side in the fall of 1949. Treatment was symptomatic and he improved. However, he experienced several recurrences, each time in connection with a sore throat. In August 1950, he was examined by an orthopaedic surgeon, who made roentgenograms of his right foot (Fig. 1). He found a peculiar peg-shaped defect of the distal end of the fifth metatarsal with an irregular excavation of the adjacent basal phalanx. A congenital defect was suspected, and the symptoms were attributed to a secondary foot strain. However, a few months later, severe pain and tenderness of the left heel occurred. This was diagnosed as an acute bursitis without careful investigation. The complaints subsided following roentgen therapy.

When he was seen in June 1951, the patient did not appear to be seriously ill; he was undersized and undernourished, but showed no skin disorder. The physical examination revealed a blue, boggy swelling

FIG. 3

Roentgenograms made on July 6, 1953. Note the progressive destruction of the metatarsal heads particularly on the left, and the periosteal changes in the shafts.

FIG. 4-A

Photomicrograph (× 78, hematoxylin and eosin stain) of the affected portion of the metatarsal bone, showing pathological changes in the area. *A:* fibrosis; *B:* chronic inflammation; *C:* osteolysis; *D:* vascular sclerosis; *E:* areolar fibro-adipose tissue.

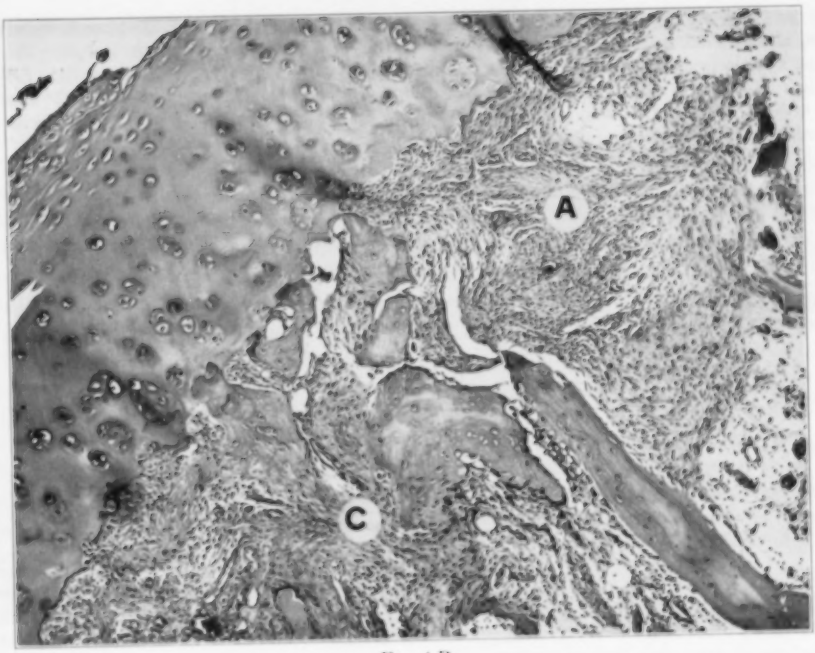


FIG. 4-B

Photomicrograph (× 78, hematoxylin and eosin stain) of an area adjacent to the articular surface, showing structural changes. *A:* fibrosis; *C:* osteolysis.

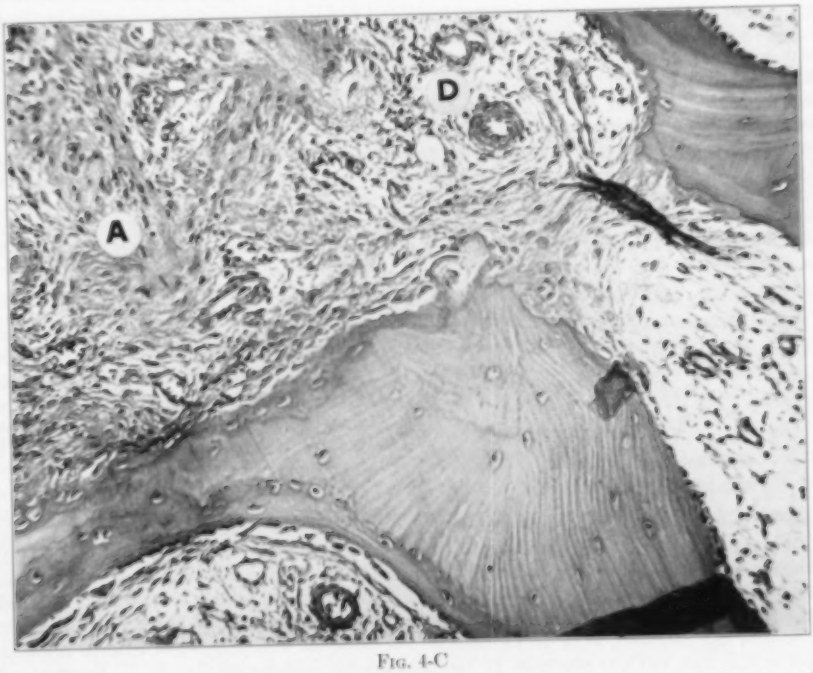


FIG. 4-C

Photomicrograph (× 156, hematoxylin and eosin stain) showing an area of fibrosis and vascular sclerosis. *A:* fibrosis; *D:* vascular sclerosis.

of the nasal mucosa; the teeth and throat appeared normal; the tonsils were absent; the lungs revealed some sibilant rhonchi; the heart, abdomen, and rectum were normal. The nervous system, including the deep reflexes, sensitivity and motility of the lower extremities, was normal. The distal end of the right foot was slightly swollen; its little toe was shortened and tender on pressure and on movements, and it appeared to be loose. Both feet were mildly cyanotic and cold; the pulsation and oscillation of the foot arteries were reduced, but they became normal after sublingual administration of nitroglycerin.

Laboratory Examinations

Urine:	
Albumin	Trace
Sugar	None
Urobilinogen	None
Sediment	Negative
Blood:	
Hemoglobin	14 grams per 100 cubic centimeters
Red blood cells	4,600,000 per cubic millimeter
White blood cells	6,400 per cubic millimeter
Neutrophils	49 per cent.
Lymphocytes	44 per cent.
Monocytes	1 per cent.
Basophils	1 per cent.
Eosinophils	5 per cent.
Sedimentation rate (Wintrobe method)	7 millimeters per hour.
Blood chemistry:	
Uric acid	2.8 milligrams per 100 cubic centimeters
Urea nitrogen	10.4 milligrams per 100 cubic centimeters
Sugar	95 milligrams per 100 cubic centimeters

The Kline and Mazzini tests were negative.
The electrocardiogram gave normal findings.
The basal-metabolism rate was −5.

Roentgenograms of the chest and of the hands were normal. Roentgenograms of both feet revealed further tapering of the defective right fifth metatarsal end and periosteal new-bone formation on the shafts of the right second and third metatarsals and second and third proximal phalanges (Fig. 2-A). There was irregular new-bone formation on the left heel (the site of the previous "bursitis"), and small irregular punched-out defects were present in the bones forming both first metatarsophalangeal joints (Fig. 2-B). No final diagnosis was made, but it appeared clear that the progressing bone destruction, as well as the new-bone formation, excluded a congenital aclasis.

Symptomatic treatment was suggested, but the patient did not return until July 6, 1953, when he experienced a new attack of continuous unbearable pain in both feet. Re-examination showed little change except severe tenderness of both feet and shortening of both little toes, especially that on the right. This toe had a typical opera-glass appearance: its skin was wrinkled and thick, and it could be pulled out easily to its original length (*doigt en lorgnette*). Findings at urinalysis, blood count, and sedimentation rate at this time were unchanged.

Blood chemistry:	
Total serum protein	6.2 grams per 100 cubic centimeters of serum
Albumin	4.25 grams per 100 cubic centimeters of serum
Globulin	1.95 grams per 100 cubic centimeters of serum
Phosphate	3.8 milligrams per 100 cubic centimeters of serum
Calcium	11.0 milligrams per 100 cubic centimeters of serum
Blood sugar	100.0 milligrams per 100 cubic centimeters of blood
Alkaline phosphatase	3.6 Bodansky units
Antistreptolysin	0 titer 166 units

Repeat roentgenographic examination of both feet showed further destruction of the bones (Fig. 3). Both fifth metatarsals now had a tapered appearance. The right little toe showed marked shortening. There was irregular destruction, narrowing, and shrinking of the heads of the second and third right metatarsals and saucer-shaped deformation of the neighboring basal phalanges. There were several small punched-out areas in these bones, as well as in those bordering both first metatarsophalangeal joints. The periosteal new-bone formation had decreased, while the osteoporosis had increased. The diagnosis of arthritis mutilans was suggested at this time and was confirmed by roentgenographic consultation (Dr. W. E. Baensch) and by bilateral biopsy on August 18, 1953 (Figs. 4-A, 4-B, and 4-C).

Course: In October 1953, severe pain occurred in the right knee joint. Roentgenograms of this joint,

as well as of various other joints, were entirely negative. Mobility of the knee was slightly restricted. This pain disappeared shortly without any specific treatment. The total white-cell count at this time was 13,000 and the differential count remained unchanged. The sedimentation rate (Wintrobe method) was 16 millimeters per hour.

COMMENT

The etiology of mutilating arthritis is unknown. Endocrine disturbances, such as hyperparathyroidism[13] and gonadal failure[22] or bacterial infections (streptococcal tonsillitis) are fairly well excluded as causative factors. The connection between psoriasis[2,4,6,15,19,21,25] and opera-glass deformity remains problematical. Hench and Slocum regard psoriatic arthritis as an entity, while several of their coworkers[7] believe that psoriatic arthritis is merely atrophic arthritis associated with psoriasis; Bauer, Bennett, and Zeller appear to reserve the term "psoriatic arthritis" only for the combination of nail involvement with disease of the terminal phalangeal joints. Various other authors have commented on the development of classical rheumatoid as well as mutilating arthritis in persons with psoriasis of long standing. However, psoriasis was absent in our patient, as well as in the majority of the previously recorded cases, and can therefore hardly play an important role in the etiology of mutilating arthritis. The relationship of arthritis mutilans to rheumatoid arthritis is evident, but the identity of both conditions remains to be proved. The clinical and roentgenographic similarity of these disorders in an advanced stage must be weighed against the limited ability of the body to react to various noxious agents affecting its joints. In addition, the following clinical differences have been noticed[20]: In typical rheumatoid arthritis, the joints of the hands and feet have limitation of motion or ankylosis, and the overlying skin is thin, atrophic, pale, shiny, and firmly attached to the bone. In contrast, the joints of mutilating arthritis have an abnormal range of motion; their overlying skin is loose and essentially unchanged. Furthermore, the site of predilection of the initial lesions of rheumatoid arthritis is the proximal interphalangeal joint and that of mutilating arthritis, the metatarsophalangeal or metacarpophalangeal joint.

Regardless of the etiology, our case seems to give us some insight into the mechanism of the unusual bone destruction. Initially, the process is entirely limited to the joint and the subchondral bone. Later, a periosteal-bone reaction occurs, demonstrable as periosteal new-bone formation; the latter can be very marked and may have an onion-peel appearance. It involves either the whole shaft or only that part adjacent to the joint. Finally, this new-bone formation is followed by an abnormal periosteal-bone absorption which causes not only a disappearance of the newly formed bone but also of the original cortex and leads to the formation of a tapering end. The latter seems to contribute to the saucer-like excavation of the base of the neighboring phalanx. It is interesting to note that Cohen had already suggested that an unusual periosteal absorption might be responsible for the bone mutilation. It is easily understandable that such a reaction was not observed in the previously reported cases, because they were in an advanced stage, and this is an initial and transitory phenomenon. However, Sterne and Schneider showed this periosteal reaction on the roentgenograms of three of their early cases of so-called "psoriatic arthritis" (Cases 1, 4, and 5). They made no comment on this finding. Also, Middlemiss noticed that a scarcely known roentgenographic feature of early juvenile rheumatoid arthritis was periosteitis. One wonders if in his patients the classical form of a rheumatoid arthritis or mutilating arthritis later developed.

DIAGNOSIS AND DIFFERENTIAL DIAGNOSIS

The diagnosis of arthritis mutilans is based upon the characteristic clinical and roentgenographic findings. Reports of laboratory examinations in this disease have been scarce and so far non-characteristic. An increased sedimentation rate and a mild normochromic anaemia have been observed in the advanced stages. Pathological examination of the

FIG. 5-A

Photograph made on March 22, 1954, showing the clinical appearance of the feet and the site of the biopsy performed on August 18, 1953.

area of destruction is also not diagnostic. The main value of biopsy lies in the exclusion of other specific diseases. Various abnormalities have been noticed: Fatty degeneration of bones and soft tissues has been described by Marie and Léri, non-characteristic granulation tissue by Stursberg and by Holroyd. Our specimen revealed "yellow-colored cancellous bone partly replaced by a firm, shiny, greyish soft-tissue mass representing an osteolytic process with chronic inflammatory reaction and sclerosis of the blood vessels" (Figs. 4-A, 4-B, and 4-C). The importance of the latter changes is unknown. Stursberg had already mentioned non-specific vascular abnormalities.

In the differential diagnosis of advanced cases of mutilating arthritis, one has to consider any form of polyarthritis. In most of the patients reported with opera-glass hands and feet there were changes characteristic of rheumatoid arthritis in various other joints of the body. However, sometimes the typical tapering of the proximal end and the cupping deformity of the distal neighboring bone were not restricted to fingers and toes, hands and feet, but were also present in other joints, —for instance, wrist, elbow, humeroscapular, and acromioclavicular joints [8,20,22]. In such cases the distal end of the ulna, the distal or proximal end of the humerus, or the clavicle have shown the peculiar pointed deformity. Of greater clinical importance is the differential diagnosis of early cases of arthritis mutilans, as demonstrated by our patient who was observed over a period of almost four years by various specialists before the disease was even suspected. A great variety of destructive and mutilating bone and joint lesions have to be considered, — such as neuropathic arthropathy, gout, congenital porphyria, scleroderma, other collagen diseases, Raynaud's disease and Raynaud's phenomenon, sarcoid, tuberculosis, tertiary syphilis, ainhum, osteochondritis dissecans (Freiberg's and Köhler's diseases), osteomyelitis (especially Madura foot), and congenital malformations. Most frequently, the disease has been confused with neuropathic bone changes such as are seen in diabetes, leprosy, and various spinal bone and cord lesions (spina bifida, meningocele, cord compression, cord tumor, myelitis, tabes dorsalis, and syringomyelia). However, neuropathic osteopathy is characterized by anaes-

FIG. 5-B

Roentgenogram of the feet made on the same day. There has been little change since 1953.

thesia and other neurological disturbances, by atrophic skin changes and perforating ulcers, and usually shows a cavus and not an opera-glass deformity. Another diagnostic difficulty may occur when mild vasospastic phenomena are associated with mutilating arthritis. However, cases with severe Raynaud's phenomenon or sclerodactylia should be excluded from the entity under discussion (as, for instance, Solomon and Stecher's patient, Case 2).

TREATMENT

Salicylates, phenylbutazone, testosterone, calciferol, and high-protein, high-caloric, high-vitamin diets have failed to influence the course of the disease in our patient. Gold had to be discontinued because toxic blood changes had occurred before an effective dosage could be administered. Cortisone in daily amounts of fifty to seventy-five milligrams orally gave excellent symptomatic relief, but it did not arrest the mutilating process (Figs. 5-A and 5-B). Roentgen therapy seemed to have improved the calcaneal exostosis subjectively and objectively. Therefore, further trial with this therapeutic modality seems to be indicated.

SUMMARY AND CONCLUSIONS

A case of mutilating arthritis has been observed almost from its beginning. The destructive process progressed locally but remained limited to the feet over a period of about four years. Therefore, this disease cannot be considered to be an advanced or a fulminating stage of rheumatoid arthritis. An explanation for the mechanism of the development of this unique deformity was suggested by the early roentgenographic findings. There is apparently an unusual periosteal reaction of the bones bordering the affected joints which leads at first to new-bone formation and later to excessive bone resorption with mutilation. Since the relationship of mutilating arthritis to psoriasis and to rheumatoid arthritis has not been established, it appears useful to consider this

entity a separate one for the purpose of early correct diagnosis. Prolonged oral administration of cortisone gives great symptomatic relief but does not seem to influence the natural course of this disease.

A review of the literature indicates that our patient is probably the youngest patient in whom this disease has been reported.

NOTE: The authors wish to acknowledge with gratitude the kind assistance of the following: Dr. Willy Baensch, Professor of Roentgenology, Georgetown University Medical Center, Washington, D. C., and Dr. Murray M. Copeland, Professor of Oncology, Georgetown University Medical Center, Washington, D. C., for review of microscopic slides, roentgenograms, and written opinion. Dr. V. A. Stembridge, Assistant Professor of Pathology, and other members of the Pathology Department, University of Texas Medical Branch, Galveston, Texas. Dr. E. B. Evans, Instructor in Orthopaedic Surgery, and Dr. Robert W. Youngblood, Resident in Orthopaedic Surgery, University of Texas Medical Branch, Galveston, Texas; and the Department of Medical Photography, University of Texas Medical Branch, Galveston, Texas.

REFERENCES

1. BAUER, WALTER; BENNETT, G. A.; and ZELLER, J. W.: Pathology of Joint Lesions in Patients with Psoriasis and Arthritis. Trans. Assn. Am. Phys., **56:** 349–352, 1941.
2. CLARKE, OWEN: Arthritis Mutilans Associated with Psoriasis. Lancet, **1:** 249–251, 1950.
3. COHEN, HENRY: Discussion on Skeletal Changes in Metabolic and Endocrine Disorders. Proc. Roy. Soc. Med., **31:** 1391–1398, 1938.
4. COMROE, B. I.: Arthritis and Allied Conditions. Ed. 4, pp. 156–159. Philadelphia, Lea and Febiger, 1949.
5. ELSON, LEO, and BURNSTEIN, NORMAN: Idiopathic Atrophy of Bones of Feet with Typical "Neurotrophic" Changes. Am. J. Med., **16:** 909–914, 1954.
6. FALK, ARTHUR: Psoriasis arthropathica, einschliesslich der sog. "hyperkeratotischen Exantheme" bei gonorrhoischen Gelenkerkrankungen. Arch. f. Dermatol. u. Syphilol., **129:** 299–331, 1920.
7. HENCH, P. S.; BAUER, WALTER; GHRIST, DAVID; HALL, FRANCIS; HOLBROOK, W. P.; KEY, J. A.; and SLOCUMB, C. H.: The Present Status of Rheumatism and Arthritis: Review of American and English Literature for 1936. (Fourth Rheumatism Review.) Ann. Int. Med., **11:** 1089–1247, 1938.
8. HOLROYD, G. T.: Two Cases of Arthritis Mutilans. British J. Radiol., **24:** 466–467, 1951.
9. KARTAGENER, M.: "Le Pied en lorgnette" bei chronischer Polyarthritis. Schweizerische Med. Wochenschr., **17:** 479–481, 1936.
10. MARIE, PIERRE, et LÉRI, ANDRÉ: Une variété rare de rhumatisme chronique: La main en lorgnette. (Présentation de pièces et de coupes.) Bull. et Mém. Soc. Méd. Hôp., Paris, **36:** 104–107, 1913.
11. MIDDLEMISS, J. H.: Juvenile Rheumatoid Arthritis (Still's Disease). Proc. Roy. Soc. Med., **44:** 805–816, 1951.
12. NAUMANN, W.: Das Krankheitsbild der Arthritis mutilans. Fortschr. a. d. Geb. d. Röntgenst., **71:** 467–471, 1949.
13. NELSON, L. S.: The Opera-Glass Hand in Chronic Arthritis. "*La Main en Lorgnette*" of Marie and Léri. J. Bone and Joint Surg., **20:** 1045–1049, Oct. 1938.
14. NIELSEN, BORGE, and SNORRASON, EGILL: Arthritis Mutilans. ("*Main et doigt en lorgnette.*") Acta Radiol., **27:** 607–616, 1946.
15. PILLMON, G. U.: Psoriatic Arthritis. *In* Clinical Radiology, vol. II, p. 562. Philadelphia, F. A. Davis Co., 1947.
16. ROBINSON, W. D.; BOLAND, E. W.; BUNIM, J. J.; CRAIN, D. C.; ENGLEMAN, E. P.; GRAHAM, WALLACE; LOCKIE, L. M.; MONTGOMERY, M. M.; RAGAN, CHARLES; ROPES, M. W.; ROSENBERG, E. F.; and SMYTH, C. J.: Rheumatism and Arthritis. Review of American and English Literature of Recent Years. (Tenth Rheumatism Review.) Ann. Int. Med., **39:** 500–618, 1953.
17. SCHINZ, H. R.; BAENSCH, W. E.; FRIEDL, E.; and UEHLINGER, E.: Roentgen-Diagnostics. First American Edition (Based on the Fifth German Edition). English Translation Arranged and Edited by James T. Case. Volume II. Skeleton (Part 2), pp. 1385–1387. New York, Grune and Stratton, 1952.
18. SCHÜLLER, J.: Über die sog. Arthritis mutilans. Münchener Med. Wochenschr., **84:** 1381–1386, 1937.
19. SHLIONSKY, HERMAN, and BLAKE, F. G.: Arthritis Psoriatica; Report of a Case. Ann. Int. Med., **10:** 537–546, 1936.
20. SOLOMON, W. M., and STECHER, R. M.: Chronic Absorptive Arthritis or Opera-Glass Hand: Report of Eight Cases. Ann. Rheumat. Dis., **9:** 209–220, 1950.
21. STERNE, E. H., JR., and SCHNEIDER, BENJAMIN: Psoriatic Arthritis. Ann. Int. Med., **38:** 512–522, 1953.
22. STURSBERG, H.: Über verstümmelnde Gelenkentzündung. Deutsche Med. Wochenschr., **61:** 5–7, 1935.
23. WEIGELDT, W.: La main en lorgnette. Münchener Med. Wochenschr., **76:** 1270, 1929.
24. WERTHEMANN, A.: Pied en lorgnette. Arthritis mutilans. Schweizerische Med. Wochenschr., **75:** 749–751, 1945.
25. ZELLNER, E.: Arthropathica psoriatica und Arthritis bei Psoriatikern. Wiener Arch. f. Inn. Med., **15:** 435–452, 1928.

TRANSPLANTATION OF THE BICEPS FEMORIS TO THE PATELLA BY THE MEDIAL ROUTE IN POLIOMYELITIC QUADRICEPS PARALYSIS *

BY GENE D. CALDWELL, M.D., SHREVEPORT, LOUISIANA

From the Shriners' Hospital for Crippled Children, Shreveport

Transplantation of the biceps femoris to the patella in order to replace or to reinforce a paralyzed or weak quadriceps extensor of the knee is not a new procedure. Fritz Lange reported a transplantation of the biceps femoris to the patella in 1900. The biceps femoris has been used singly or in various combinations with the medial hamstrings, gracilis, sartorius, and tensor fasciae femoris for over fifty years with reported good results in most cases. Lateral dislocation of the patella following transplantation of the biceps femoris alone has been a frequent complication. Recurvatum of the knee may occur following transplantation of both the biceps femoris and the medial hamstrings unless the gastrocnemius is unusually strong. It has been generally agreed that the biceps femoris will

TABLE I

COMPARATIVE END RESULTS

	Total No. of Cases	No. of Cases Followed More than Two Years	End Results: Good		Fair		Poor		Patellar Dislocation		Recurvatum	
			No.	*Per cent.*	*No.*	*Per cent.*	*No.*	*Per cent.*	*No.*	*Per cent.*	*No.*	*Per cent.*
Medial transplantation	39	33	27	69.2	6	15.4	6	15.4	0	0	2	5.1
Lateral transplantation	18	13	11	61.1	4	22.2	3	16.7	8	44.4*	3	16.7
Transplantation of biceps femoris and semitendinosus	6	6	4	66.6	1	16.7	1	16.7	2	33.3†	0	0

* Of cases followed more than two years, 61.5 per cent.
† Of cases followed more than two years, 50 per cent.

effectively stabilize the knee and that it is much more effective than the medial hamstrings when used alone to compensate for a paralyzed or weak quadriceps. The frequent occurrence of chronic patellar dislocation following transplantation of the biceps femoris to the patella by the usual lateral route has led some surgeons to abandon this procedure entirely. The method of transplanting the biceps femoris to the patella by the medial route presented here is a procedure which eliminates the objectionable patellar dislocation and makes it possible to avoid genu recurvatum by leaving undisturbed the functioning medial hamstrings.

Although transplantation of the biceps femoris by the medial route decidedly redirects the course of the tendon to its new insertion and although it may appear to be contrary to an accepted precept of tendon transplantation, the functional end results have been slightly better than those obtained by older methods (Table I), and the objectionable complication of patellar dislocation has been completely eliminated.

* Read at the Annual Meeting of the American Medical Association, Orthopaedic Section, San Francisco, California, June 24, 1954.

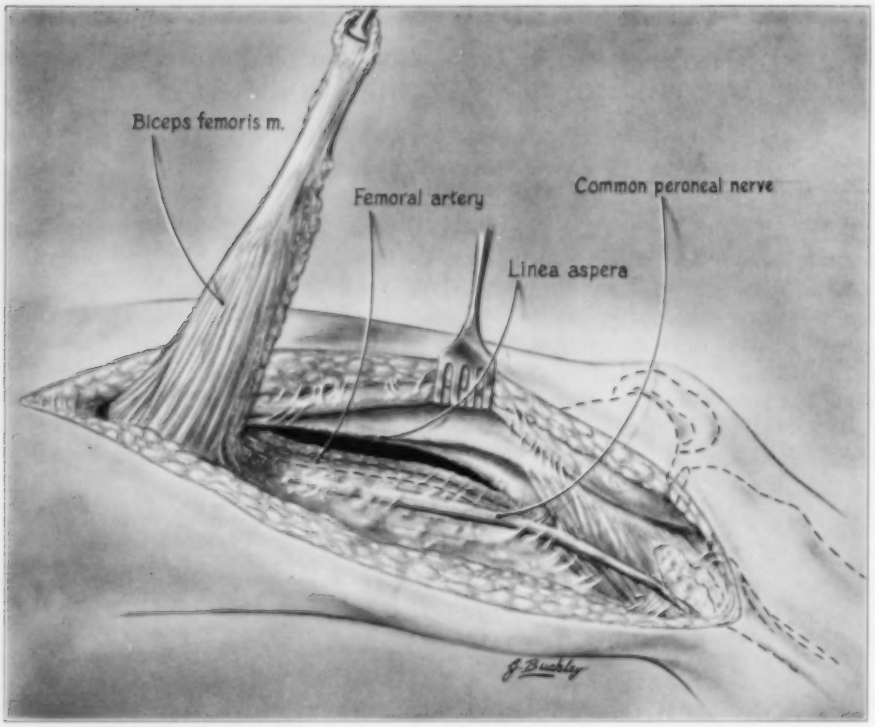


FIG. 1

INDICATIONS

This muscle transference is indicated in patients in whom paralysis of the quadriceps necessitates either a brace or hand-to-knee walking in order to stabilize the knee. The biceps femoris to be transplanted should be of good or normal power. Any fixed flexion deformity at the knee must be corrected prior to the tendon transplantation. A good hip extensor and gastrocnemius are very helpful, but their absence does not contra-indicate this muscle transference. Recurvatum may still be expected following the transplantation if the medial hamstrings and the gastrocnemius are not functioning.

OPERATIVE TECHNIQUE

The first of these operations was performed by Dr. Herbert A. Durham at the Shriners' Hospital for Crippled Children in Shreveport in 1935. The following operating technique varies in only a few small details from the original technique as used by Dr. Durham.

Under high-tourniquet ischaemia, the biceps femoris is exposed by a posterolateral longitudinal incision, starting about two and a half centimeters distal to the head of the fibula and extending proximally to about the junction of the middle and upper thirds of the thigh. The biceps femoris tendon is divided at its insertion to the fibula as far distally as possible, care being taken to avoid injury to the underlying common peroneal nerve. It has not been necessary to obtain extra length of the tendon by including the deep fascia distal to the point of insertion. The tendon and muscle is dissected upward and freed of its soft-tissue attachments well up to the upper third of the thigh. The distal two thirds of the short head of origin of the muscle is detached from the femur, with care to avoid damaging the nerve and blood supply which enter in the upper third. Beginning at the most proximal point of the detached short head of the biceps femoris, the intermuscular septa

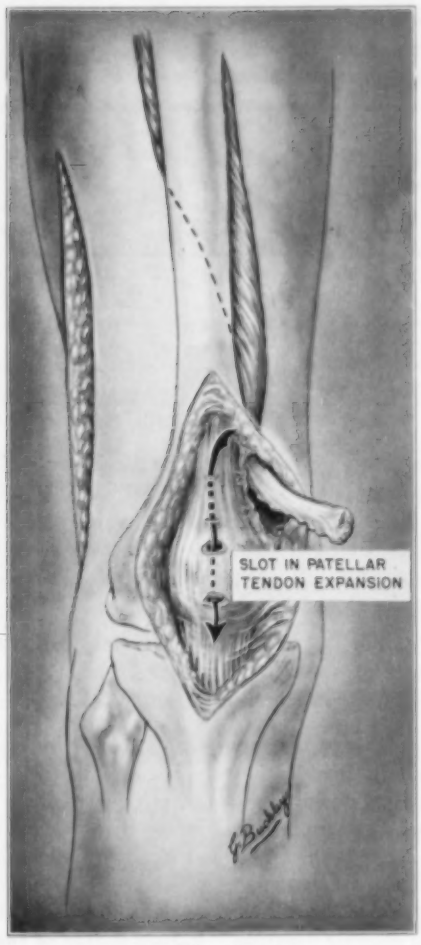


FIG. 2

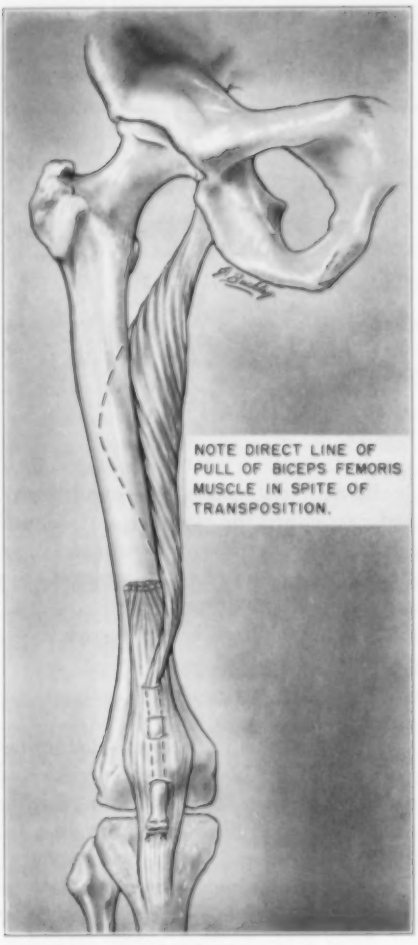


FIG. 3

are stripped from their attachment to the linea aspera distally a full ten to thirteen centimeters, the perforating vessels being preserved. The septa are tight and inelastic and must be carefully divided at several points in order to secure relaxation and to permit free transference of the biceps femoris muscle behind the femur to the medial side of the thigh without danger of the muscle being constricted between the intermuscular septa and the femur (Fig. 1).

Next, the patella and the quadriceps tendon are exposed by a medial parapatellar incision. A longitudinal osseous tunnel is prepared through the anterior superficial portion of the patella with a five-eighths-inch osteotome. A tunnel is then made by blunt dissection between the rectus femoris and the vastus medialis, extending posteriorly and obliquely proximalward to the opening made by stripping the linea aspera. This tunnel must be large enough to permit free passage of the biceps femoris tendon and a portion of its muscle belly. The biceps femoris tendon is first passed posteriorly and medially around the femur, deep to the vastus medialis, then obliquely distalward, and, finally, anteriorly to the patella (Fig. 2). With the knee held in full extension, the tendon is pulled through the osseous tunnel in the patella by means of a heavy silk suture. Strong upward traction on the patella

TABLE II

ACTIVE EXTENSION OF KNEE AGAINST GRAVITY
IN THIRTY-NINE CASES OF TRANSPLANTATION BY THE MEDIAL ROUTE

Range of Extension	To 180 Degrees		From 150 to 180 Degrees		Less than 150 Degrees		0 Degrees	
	No. of Cases	*Per cent.*	*No. of Cases*	*Per cent.*	*No. of Cases*	*Per cent.*	*No. of Cases*	*Per cent.*
End Results	10	25.6	17	43.6	10	25.6	2	5.1
Good 27	9	33.3	14	51.8	4	14.8	0	
Fair 6	1	16.7	3	50.0	2	33.3	0	
Poor 6	0		0		4	66.6	2	33.3

with a bone hook facilitates this step. The tendon is securely fixed into the patella by multiple silk mattress sutures. The quadriceps tendon is split or an anteromedial flap is raised in order to embed the biceps femoris tendon in it. This further secures the tendon attachment and also permits a more direct upward pull on the patella by the transplanted muscle. It will be noted that despite the apparently indirect circuitous route of the transplanted muscle the actual direction of pull is quite straight and direct (Fig. 3). The extremity is immobilized in a well padded cast with the knee in full extension. The cast is immediately bivalved.

AFTER-CARE

Immobilization in plaster is maintained for a period of four weeks. The cast is then removed, and gradual active exercises and muscle re-education are begun. Muscle re-education has been rapid in these patients. Except during periods of physical therapy, immobilization in full extension for an additional four weeks is maintained by a posterior splint. After four weeks of muscle re-education, there is usually sufficient active power in the transplanted biceps femoris to maintain the knee extended against gravity and to permit gradual weight-bearing. These patients are not encouraged to flex the knee, but great stress is placed upon active extension and patellar "setting". Forced flexion of the knee must be guarded against for a period of at least two months. No braces are provided to guard against sudden flexion of the knee after the patients have been permitted active walking.

END RESULTS

From 1923 to 1935, twenty-two transplantations of the biceps femoris to the patella by the lateral route and six combined transplantations of the biceps femoris and semitendinosus were done at the Shriners' Hospital for Crippled Children in Shreveport. From 1935 to 1953, forty-one transplantations of the biceps femoris were done by the medial route. Four lateral and two medial transplantations in these two groups were excluded from this study because follow-up notes were inadequate for accurate evaluation. This leaves eighteen lateral, six combined, and thirty-nine medial transplantations upon which conclusions may be based. Only the thirty-nine transplantations by the medial route are analyzed in detail.

End results were classified simply as *good*, *fair*, or *poor*, with functional stability of the knee as the sole criterion, regardless of the degree to which the knee could be actively extended against gravity or resistance. The end results were classified as *good*, if the knee was stable under normal activity and fatigue; *fair*, if the knee gave way occasionally

TABLE III

FUNCTIONAL RESULTS IN THIRTY-NINE CASES OF TRANSPLANTATION BY THE MEDIAL ROUTE

End Result	Hip Extensor			Gastrocnemius			Both Fair or Less	Both Fair or Better
	Good	Fair	Poor	Good	Fair	Poor		
	No.	*No.*	*No.*	*No.*	*No.*	*No.*	*No.*	*No.*
Good 27	15	9	3	10	10	7	7	14
Fair 6	5	1	0	4	0	2	1	5
Poor 6	1	2	3	3	2	1	2	2

with fatigue, mis-step, or other incident; and *poor*, if the knee was unstable and still required some support in walking. Since many of these patients were handicapped by paralytic disabilities other than weakness of the knee, "normal activity" should be more clearly defined as that activity within limits imposed by other concomitant physical handicaps.

At the time of this study, the average follow-up of the medial transplantations was seven years (longest follow-up, eighteen years); of the lateral transplantations, eight and one-half years (longest follow-up, twenty-nine years); and of the combined biceps femoris and semitendinosus transplantations, four and one-half years (longest follow-up, ten years). The ages of the patients ranged from six to fourteen years, the average age being ten and one-half years. As noted in Table I, there is very little difference in the functional end results of the three groups. Lateral dislocation of the patella, however, occurred in 44.4 per cent. of the total number of patients who had lateral transplantations and in 61.5 per cent. of those with a follow-up study of over two years. Strangely, two instances of patellar dislocation were noted in patients who had the combined biceps femoris and semitendinosus transplantations, and in both patients the semitendinosus muscle power had been rated as normal. It is possible for a strong biceps femoris to cause patellar dislocation in spite of a normal semitendinosus attached to its medial border. Full active knee extension to 180 degrees by the transplanted biceps femoris is not necessary to obtain stability of the knee.

Of the twenty-seven patients with *good* results in transplantations by the medial route, fourteen (51.8 per cent.) could not actively extend the knee to 180 degrees, the limitation varying from a position of 150 to 180 degrees, while four (14.8 per cent.) could not extend the knee as far as 150 degrees. The functional end results were comparable between the group of patients who had the ability to extend the knee to 180 degrees and the group whose range was between 150 and 180 degrees. All of the six *poor* end results or failures occurred in those patients whose active extension was less than 150 degrees.

While it may be conceded that a strong hip extensor and gastrocnemius definitely contribute to stability of the knee, a study of Table III would seem to indicate that these factors do not materially influence the functional end results of the biceps femoris transplantations. The distribution of *good*, *fair*, and *poor* hip-extensor and gastrocnemius muscle power is fairly parallel in the three functional end-result classifications (Table III). In seven patients of the twenty-seven who had *good* results, both the hip extensor and the gastrocnemius were rated as *fair* or less in power. A satisfactory end result with stability of the knee may be obtained even though other stabilizing factors are absent.

Preoperatively, of the thirty-nine tendon transplantations in this series, nineteen patients had from a trace to fair power in the quadriceps, while twenty had no demonstrable power in the knee extensor. Reinforcement of a weak quadriceps extensor by a good biceps femoris should produce a better result than a complete replacement of an absent quadriceps. That this is true is illustrated in Table IV.

TABLE IV

COMPARISON OF PREOPERATIVE MUSCLE POWER WITH END RESULTS IN THIRTY-NINE TRANSPLANTATIONS BY THE MEDIAL ROUTE

Preoperative Muscle Power	No. of Cases	End Results: Good *No.*	Fair *No.*	Poor *No.*
Quadriceps				
Fair to trace	19	15	3	1*
No power	20	12	3	5
Biceps Femoris				
Poor to fair	3	1†	0	2

* Poor biceps femoris transplanted to fair quadriceps.
† Fair biceps femoris transplanted to fair quadriceps.

A biceps femoris with less than good power was transplanted in three patients. In two of these patients, failure resulted. One good result was obtained by transplanting a fair biceps femoris into a fair quadriceps, the combined power of the two muscles being adequate to completely stabilize the knee.

Table V shows the comparative range of flexion and extension of the knee by the transplanted biceps femoris with the hip at a position of 90 degrees of flexion and with the hip at 180 degrees of extension. Very little appreciable difference is noted in the range of active knee extension in these twelve patients. Note also that knee flexion is limited in all of these twelve patients (Table V). In the entire series, the greatest degree of flexion noted was to a position of 55 degrees. Limitation of knee flexion apparently has no more bearing upon the functional end result than does a mild limitation of active extension.

ANALYSIS OF FAILURES

Of the thirty-nine medial transplantations in this series, six (15.4 per cent.) were rated as *poor*, or failures. Postoperative infection in one patient resulted in complete loss

TABLE V

RANGE OF ACTIVE KNEE FLEXION AND EXTENSION IN TWELVE CASES OF TRANSPLANTATION BY THE MEDIAL ROUTE

No. of Years Follow-up	End Result	Sitting Erect, Hip at 90 Degrees: Flexion (*Degrees*)	Sitting Erect, Hip at 90 Degrees: Extension (*Degrees*)	Lying Supine, Hip at 180 Degrees: Flexion (*Degrees*)	Lying Supine, Hip at 180 Degrees: Extension (*Degrees*)
1.5	Good	70	150	70	150
2	Good	55	160	50	150
2	Fair	55	125	55	120
2.5	Good	70	150	70	150
3	Good	60	115	70	140
3	Good	90	160	100	155
3.5	Fair	85	160	100	165
4	Good	65	145	65	145
4.5	Good	80	150	80	150
13	Fair	60	180	55	170
14	Fair	60	160	60	155
14	Good	80	155	80	155

of the transplanted muscle. In another, forced passive knee flexion by a therapist one week after institution of active exercises resulted in complete loss of function of the transplanted biceps femoris.

In the third case, although the knee was stable under weight-bearing, the result was rated as *poor*, because of back-knee with a strong gastrocnemius. Only a trace of extensor power at the knee resulted from transplantation of a fair biceps femoris to the patella, and certainly in this case stability could not be attributed to the transplanted biceps femoris.

Transplantation of a fair biceps femoris to a quadriceps with only a trace of power resulted in the fourth failure. The functional result in this case might have been rated as *fair*, since the knee was reasonably stable under weight-bearing but gave way too frequently with fatigue.

There was no apparent reason noted for failure in the remaining two patients. One had had a transplantation by the lateral route in 1933 which resulted in failure. Technical errors could well be the reason for these failures.

SUMMARY AND CONCLUSIONS

1. The biceps femoris, when transplanted to the patella by the medial route in order to compensate for quadriceps paralysis, gives as good a functional result as when transplanted by other methods.

2. The objectionable complication of patellar dislocation is completely eliminated when the biceps femoris transplantation is done by the medial route.

DISCUSSION

Dr. N. J. Giannestras, Cincinnati, Ohio: It is indeed a pleasure to discuss Dr. Caldwell's paper. Here is a procedure which completely eliminates patellar dislocation. The 15.4 per cent. failure rate is not due to failure of the transplanted muscle to function, but is due to technical and unfortunate postoperative complications. I am confident that, had Dr. Caldwell analyzed only those end results in patients who were operated upon during the past ten years, his percentage rate of failures would have been much smaller.

It was my privilege to observe Dr. Caldwell use this procedure at the Shriners' Hospital in Shreveport, and subsequently I have performed the operation on three different occasions. There is only one word of caution which I should like to give,—this operation is not one which can be performed by the timid orthopaedic surgeon. The skin incision and the dissection of the short head of the biceps femoris should be very adequate, and, if the stripping of the intermuscular septa from the linea aspera is not extensive, the procedure will fail.

I should like to report a case in which this transplantation was performed because of traumatic loss of the quadriceps muscle group. The patient was initially seen in November 1951, after an automobile accident. The condition of his right lower extremity at the time of admission was precarious. He had sustained an open fracture of the supracondylar region of the femur with complete stripping of the musculature from the distal eight centimeters of the proximal fragment, complete loss of the quadriceps, and partial disruption of the vastus medialis.

It was necessary to debride the entire quadriceps, as well as part of the vastus medialis, and to excise the patella. Primary closure of the skin was carried out, and the fracture was aligned and immobilized. The fracture finally united in thirteen months.

In September 1953, twenty-two months following the injury, transplantation of the biceps femoris to the patellar tendon was performed.

Eight months following the transplanation of the biceps femoris by the medial route, the patient was able to stand on the right lower extremity and bear his entire weight, in spite of the fact that there was no quadriceps power and no quadriceps musculature present. The entire power for extension and stability of the knee was supplied by the biceps femoris in its transplanted position. He demonstrated extension to 170 degrees and flexion to 85 degrees. The lack of the last 10 degrees of extension is due to capsular contracture of the posterior aspect of the knee.

The patient has now returned to his occupation as a tobacco farmer and is able to perform a full day's work without any fatigue of the leg or thigh.

Dr. Frederic C. Bost, San Francisco, California: Probably no paralytic condition of the lower extremity merits greater consideration than that which leaves a knee weak because of quadriceps paralysis. Paralysis involving the foot or the hip may be taken care of by various means, including arthrodesis. It is

(*Continued on page 360*)

THE TREATMENT OF EXPERIMENTAL ARTHRITIS IN RABBITS WITH HYDROCORTISONE ACETATE *

BY R. H. RAMSEY, M.D., AND J. ALBERT KEY, M.D., ST. LOUIS, MISSOURI

From the Department of Surgery, Washington University School of Medicine, The David P. Wohl, Jr., Memorial Hospital, St. Louis

Having had some experience with the clinical use of local injections of hydrocortisone acetate in the treatment of bursitis, arthritis, and allied conditions [2], we wished to learn more about the action of this potent adrenal steroid. Hench and his coworkers suggested that cortisone and pituitary adrenal corticotropic hormone act by creating a shieldlike buffer between the tissues and a variety of irritants. Selye produced subcutaneous pouches in rats by the injection of twenty-five cubic centimeters of air and then produced a granulomatous reaction in the wall of the pouch by injecting corn oil or diluted croton oil into the pouch. Ten days later pure croton oil was injected into the pouches and this caused necrosis of the skin in all animals except those in which the wall of the pouch was very thick (900 micra). The thickening of the granulomatous wall was markedly decreased in those animals in which hydrocortisone had been injected into the pouch at the same time as the irritant. In such animals the necrosis was more extensive and the area of necrosis seemed to vary inversely with the thickness of the wall of the pouch. Selye concluded that hydrocortisone does not form a barrier between the tissues and potential pathogens, because the necrosis is aggravated while the protective inflammation is inhibited by the hormone. He believed that the principal action of the steroids appears to be that they inhibit the development of granulomatous barriers between irritants and vital tissues.

In this paper we wish to report the results of some experiments in which a rather mild inflammatory reaction was produced in the knee joints of rabbits by the injection into each joint of a suspension of a 10 per cent. solution of oil of turpentine in water or of talc in water. The joints were then treated by intra-articular injections of hydrocortisone.

MATERIAL AND METHODS

Twenty-two normal adult rabbits were used. The material was injected into the joints in the following manner: The lower extremity was held in extension and, after the skin had been wet with alcohol, a 21-gauge needle was inserted through the patellar tendon and fat pad until its tip was felt to be between the patella and the femur. The material was then injected into the joint cavity. The needle was held with its long axis almost parallel to that of the femur; if this was done, the joint usually could be entered without much difficulty. As the material was injected, the patellar pouch could be felt to distend. It is important that the material be injected into the joint cavity and not into the periarticular tissue.

At intervals after one or more injections of the hydrocortisone the animals were sacrificed and the knee joints were examined in the gross. Portions of the synovial tissues were then removed and prepared for microscopic study. The animals were divided into two groups: The rabbits in Group I were injected with turpentine and those in Group II were injected with talc.

Group I

Into each knee of twelve adult rabbits two cubic centimeters of a sterile 10 per cent. suspension of oil of turpentine in water was injected. The left knees served as

* Read at the Orthopaedic Section, Forum on Fundamental Surgical Problems, American College of Surgeons, Chicago, Illinois, October 7, 1953.

controls and the right knees were treated locally by injections of hydrocortisone into the joint. In alternate rabbits a small amount of India ink was added to the turpentine when it was injected into the knee. The treatment was begun forty-eight hours after the injections of the irritant, half of the rabbits receiving 2.5 milligrams of hydrocortisone in the right knee, while the others received 7.5 milligrams.

The animals were divided into three groups of four each. The first group received only one injection of hydrocortisone and were sacrificed six days later, or eight days after the injection of the irritant. The second group received a second injection of hydrocortisone six days after the first treatment and were sacrificed one week later, or fifteen days after the injection of the irritant. The third group received seven weekly injections of hydrocortisone beginning forty-eight hours after the injection of the irritant and were sacrificed seven days after the last treatment, or fifty-eight days after the beginning of the arthritis.

Group II

Each of this group of ten rabbits received two cubic centimeters of a sterile 10 per cent. suspension of talc in water into each knee. The left knees served as controls and the right knees were treated locally with hydrocortisone. Treatment was begun five days after the injection of the talc, half of the animals receiving 2.5 milligrams, while the others received 7.5 milligrams at each dose. The first group of four animals received two treatments at five and twelve days; the second group of two animals received three treatments at five, twelve, and nineteen days; and the third group of four animals received six treatments at five, twelve, nineteen, twenty-six, thirty-three, and forty days. All animals were sacrificed one week after the last treatment, or nineteen, twenty-six, and forty-seven days after the onset of the arthritis.

OBSERVATIONS

Group I

On gross examination both knees of all these rabbits revealed evidence of inflammation and in the animals which had received India ink the synovial tissues were also stained grey or black. In all four of the eight-day rabbits both the control and the treated knees revealed evidence of moderate inflammation, with abnormal reddening and injection of the synovial surfaces and excess fluid in the joints. There was almost no difference in the appearance of the four knees, except that the amount of cloudy, whitish exudate was greater in the controls than in the treated knees. Moreover, there was no noticeable difference between the knees which had received 2.5 milligrams and those which had received 7.5 milligrams of hydrocortisone.

In the four fifteen-day rabbits the inflammation appeared to be more intense than in the eight-day group and the synovial tissues seemed to be thickened. Here again there was no significant difference between the treated and the untreated knees or between those which had received 2.5 milligrams and those which had received 7.5 milligrams of hydrocortisone.

In the fifty-eight-day rabbits there was a definite difference between the controls and the treated knees (Fig. 1). In the controls there was moderate to severe injection of the synovial membrane, which was considerably thickened and in some places exhibited villus formation, and there was some pannus formation and irregular erosion of the articular cartilage. The treated knees showed only slight redness and injection of the synovial tissues; they showed no evidence of thickening and the articular cartilage was normal in appearance.

In the six rabbits of this series which had received a mixture of India ink and oil of turpentine, the synovial tissues were grey or black in color, the intensity of the staining varying directly with the amount of India ink which had been deposited in a given area.

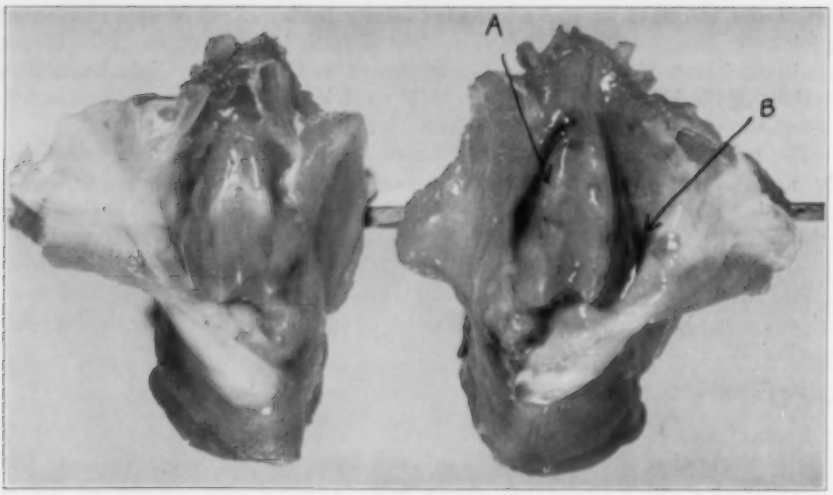


FIG. 1

Knee joints of a five-pound white rabbit which had received an injection of two cubic centimeters of 10 per cent. suspension of oil of turpentine into each knee. The right knee (left in the photograph) was treated with seven weekly injections of 2.5 milligrams of hydrocortisone, beginning forty-eight hours after injection of the irritant. The left knee (right in the photograph) remained untreated. The rabbit was sacrificed fifty-eight days after injection of the irritant. Note the thickening and hyperaemia of the synovial tissue (arrow *B*) and erosion of the articular cartilage (arrow *A*) in the untreated knee.

Grossly there was no appreciable difference in the reaction of the joint to the India ink between the treated and the control knees.

On microscopic examination of the synovial tissues from the eight-day rabbits, the specimens from the left or control knee showed a moderate amount of proliferation of the surface cells of the synovial membrane, and the underlying subsynovial tissues were moderately infiltrated with small and medium-sized round cells. The sections from the right or treated knees showed a similar reaction, but it was less marked in degree.

In the fifteen-day joints the reaction was similar in character and in some sections the reaction appeared to be more intense than in the eight-day joints. Here again, the inflammation was more marked in the controls than in the treated joints, but the difference was not great. Similar conditions were found in the fifty-eight-day joints, and in some of those which had been treated with seven injections of hydrocortisone the synovial tissues were normal in appearance.

In all of the joints which had received India ink in addition to the turpentine, the greater part of the carbon particles had been phagocytized by mononuclear cells and these had passed through the synovial surface and had congregated in the deeper tissues adjacent to the fibrous capsule of the joint. There was also a small amount of very finely divided carbon in the synovial surface cells and in the subsynovial connective-tissue cells. In the older joints the phagocytic cells which had contained the ink had apparently died and disappeared and the ink formed large black extracellular masses deep in the subsynovial tissues; these masses were surrounded and more or less encapsulated by connective-tissue cells. Figures 3-A and 3-B demonstrate the intensity of the microscopic reaction in the untreated knees of the rabbits sacrificed at fifty-eight days.

In the sections from some of the earlier joints the ink particles appeared to be more diffusely scattered through the tissues and less completely phagocytized in the treated joints than in the controls.

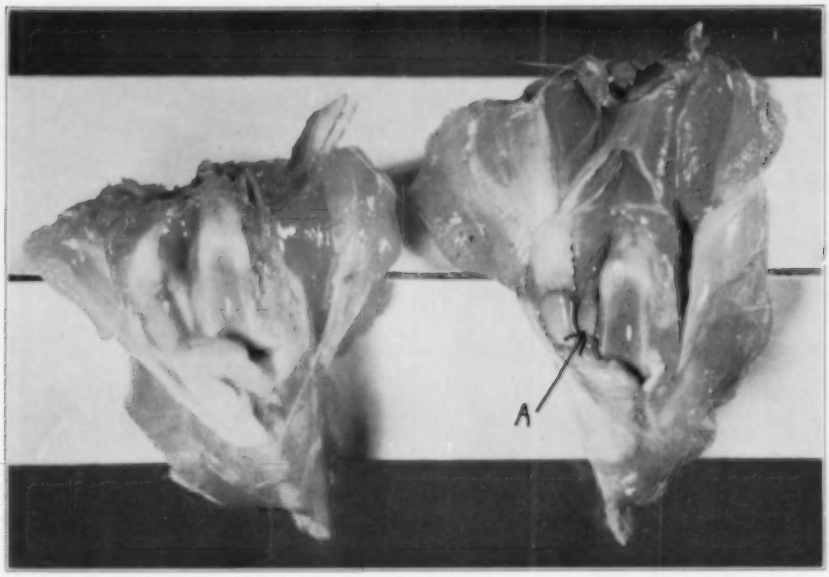


FIG. 2

Knee joints of a five-pound white rabbit which had received an injection of two cubic centimeters of a sterile 10 per cent. talc suspension into each knee. The right knee (left in the photograph) was treated with injections of 2.5 milligrams of hydrocortisone on the fifth and twelfth days after injection of the irritant. The left knee (right in the photograph) was untreated. The rabbit was sacrificed nineteen days after injection of the irritant. Note particularly the aggregates of talc in the fibrin clot (arrow *A*), as well as increased hyperaemia in the untreated knee.

Group II

By gross examination all the joints revealed evidence of inflammation and granuloma formation in the synovial tissues. In the nineteen-day joints (Fig. 2) the left, or control, knees exhibited marked redness and injection, and moderate thickening of the synovial tissues, with aggregates of talc adherent to the synovial surface. In some areas the articular cartilage was dull in appearance and showed a few small areas of erosion. In the treated joints the synovial changes were similar in character, but less in degree, and the cartilage was smooth and glistening. There was no appreciable difference between the knees which had received 2.5 milligrams and those which had received 7.5 milligrams of hydrocortisone.

In the twenty-six-day and forty-seven-day joints the talc had largely disappeared from the joint cavity and the evidences of inflammation were less marked. In other words, these joints appeared to be recovering from the insult offered by the talc and there was very little difference between the treated and the untreated knees.

On the microscopic examination the nineteen-day joints exhibited rather marked proliferation of the synovial surface cells and infiltration of the subsynovial tissues with small and medium-sized round cells. Some crystals of talc were present in the loose areolar or fatty tissues just beneath the synovial membrane and were partly or completely surrounded by macrophages, connective-tissue cells, and foreign-body giant cells. The greater part of the talc, however, was present as aggregates of crystals which were adherent to the synovial surface and were being invaded by fibroblasts, macrophages, and foreign-body giant cells, and a new synovial surface had formed on the exposed surface of the granulomatous mass. Figures 4-A and 4-B show the microscopic pathology in the untreated knee of a nineteen-day rabbit.

In the treated joints a similar reaction was present, but it was less in degree and

FIG. 3-A

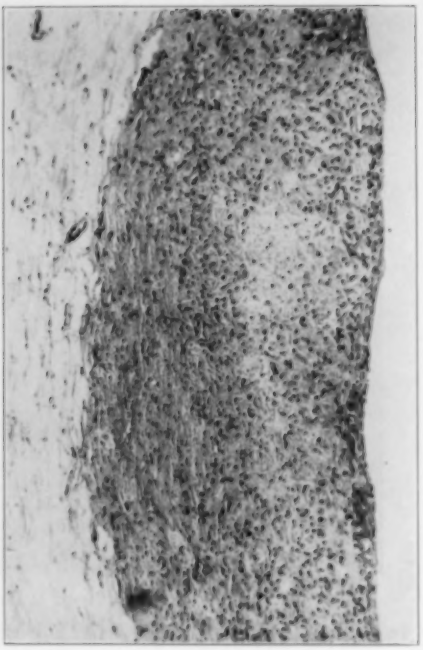


FIG. 3-B

High-power (× 400) and low-power (× 100) photomicrographs of the synovial tissue of the untreated knee in a rabbit sacrificed fifty-eight days after injection with turpentine. The treated knee showed essentially normal synovial tissue.

the granulomatous masses were less densely populated with cells than were the controls. Here again we could detect no difference between the joints which had received 2.5 milligrams and those which had received 7.5 milligrams of hydrocortisone.

In the twenty-six-day joints the reaction was similar and the process of surrounding the talc crystals and extruding them from the joint cavity was more advanced. This was even more true of the fifty-eight-day joints and in these the synovial surface in many areas in both the treated and the control joints was normal in appearance. However, even in the fifty-six-day experiments the talc granulomata contained relatively fewer cells in the treated joints than they did in the controls.

An additional five rabbits were used to determine whether there was gross or microscopic effect from the injection of hydrocortisone into the knee joint. In each of the five rabbits the right knee was injected with five milligrams of hydrocortisone suspension made up to one cubic centimeter with normal saline solution. The left knee of each of these rabbits was injected at the same time by the same technique with one cubic centimeter of sterile normal saline solution. The rabbits were sacrificed at twenty-four, forty-eight, seventy-two, ninety-six, and 120 hours after the injections; the knee joints were opened and examined grossly and a strip of synovial tissue was removed for section and staining with hematoxylin and eosin.

Grossly none of the joints showed any abnormality which was not attributable to the trauma of insertion of the needle. None of the drug particles could be visualized in any of the knees injected with hydrocortisone. The microscopic examination of the synovial tissue revealed no inflammatory or other changes, except in the area of needle penetration where some recent hemorrhage and mild cellular infiltration were seen.

This portion of the experiment is taken as evidence that no immediate harmful

FIG. 4-A

FIG. 4-B

High-power (× 400) and low-power (× 100) photomicrographs of a typical section of synovial tissue of the untreated knee of a rabbit sacrificed nineteen days after injection with talc. This represents the height of the inflammatory response to the irritant, following which recovery to normal occurred in the next two to three weeks. The treated knee showed a similar but less intense reaction.

effect is caused by the presence of the hydrocortisone in the joint. The wide clinical use of this drug intra-articularly without serious drug reaction would confirm this finding.

DISCUSSION AND CONCLUSIONS

These observations tend to support Selye's hypothesis that the effect of the adrenal steroids is to inhibit the capacity of the tissues to respond to a noxious stimulus by inflammatory reaction. In these experiments, the inflammatory response was well under way before the hydrocortisone was introduced into the injured tissues; however, the arthritis caused by the turpentine and the granulomatous process by which the talc was isolated from the joint cavity continued to progress. The gross appearance showed a diminution of the vascular-dilatation element of inflammation in most instances on the treated sides and the microscopic appearance showed as a rule fewer infiltrating phagocytic cells on the treated sides. These findings suggest not only that there is an inhibition to the progress of the inflammatory response, but also that the tissues tend to return to a normal state more rapidly after treatment. In our experiments, the injury was relatively mild and the hydrocortisone seemed to exert a favorable influence on recovery, although the difference between the treated and the untreated sides was not great. If the hydrocortisone had been administered at the time of the injection of the irritant, it is probable that the effect would have been more marked.

There was no tendency for the hydrocortisone to accentuate the damage and to cause necrosis, as was noted by Selye in his experiments with croton oil. It seems probable to us, however, that the thick barrier between the skin and the inside of the granuloma pouch in Selye's experiments, in which the skin did not become necrotic, was a mechanical one and that the steroid really did not actually enhance the necrotizing effect of the

croton oil. In more severe injury to tissues, as Selye showed in his experiments, the anti-inflammatory effect of hydrocortisone may result in greater damage to the tissues involved, because the inflammatory reaction may have a protective effect by creating a shield.

In the clinical application of these principles, it seems logical to assume that hydrocortisone would be most useful in those pathological conditions which are inherently localized and self-limited, in which the symptoms are largely due to the inflammatory response *per se*, and which are either progressing or in which the noxious agent is continuing to act.

REFERENCES

1. Hench, P. S.; Slocumb, C. H.; Polley, H. F.; and Kendall, E. C.: Effect of Cortisone and Pituitary Adrenocorticotropic Hormone (ACTH) on Rheumatic Diseases. J. Am. Med. Assn., **144**: 1327–1335, 1950.
2. Ramsey, R. H., and Key, J. A.: The Use of Hydrocortisone (Compound F) by Local Injection in Arthritis and Allied Conditions. Missouri Med., **50**: 604–606, 1953.
3. Selye, Hans: On the Mechanism through Which Hydrocortisone Affects the Resistance of Tissues to Injury. An Experimental Study with the Granuloma Pouch Technique. J. Am. Med. Assn., **152**: 1207–1213, 1953

DISCUSSION

Transplantation of the Biceps Femoris to the Patella

(*Continued from page 353*)

generally agreed that for the weak knee, arthrodesis is extremely undesirable. Therefore, any procedure which may be devised to re-enforce the weakened knee by muscle transplantation is desirable, for otherwise the patient must either rely upon a brace which will lock the knee or he must use his hand against the femur to prevent the knee from buckling forward.

Dr. Caldwell has done well, therefore, to again call our attention to operations which may re-enforce the weakened quadriceps or in some way take the place of the completely paralyzed quadriceps. He has presented an excellent review of an operation which he has found useful in overcoming the quadriceps paralysis.

Lateral dislocation of the patella is well known to all of us, and it follows either the single transplantation of the biceps femoris by the ordinary lateral route or the transplantation of the biceps femoris in combination with some weaker medial hamstring. Nothing is more discouraging than to have the apparently successful pull of the re-enforcing tendon vitiated by the lateral displacement of the patella. The results presented by Dr. Caldwell would indicate that this dislocation is avoidable if the biceps femoris can be transplanted about the medial side of the femur.

I have had no experience with the method presented by Dr. Caldwell, but I have used either the transplantation of the biceps femoris with some other medial hamstring or the transplantation of the sartorius and tensor fasciae femoris as a means of re-enforcing or replacing the paralyzed quadriceps. Experience has demonstrated that the use of the tensor fasciae femoris and sartorius muscles will rarely, if ever, give an extension of the knee equal to that obtained by transplantation of the biceps femoris. Transplantation of the biceps femoris is, therefore, the most desirable means of correcting the quadriceps paralysis.

Dr. Caldwell has stated clearly indications for the hamstring transplantation, and these require no further elaboration.

Since the nerve supply of the long head of the biceps femoris and also that of the short head are from different sources, the long head of the biceps femoris can be dissected free practically up to its origin. The medial transference may, therefore, be a direct one and placed in a fairly straight line. The nerve supply is of such a nature that it can be preserved even though the muscle is dissected high up toward the ischial tuberosity.

Dr. Caldwell is certainly to be congratulated for his excellent presentation of what appears to be a most useful operation.

TRACTION ARTHROGRAPHY OF THE HIP JOINT

A Method of Roentgenographic Visualization of the Articular Space of the Hip Joint

BY SAMUEL SCHORR, M.D., AND MYER MAKIN, M.B., M.R.C.S., JERUSALEM, ISRAEL

From the Rothschild Hadassah University Hospital and Medical School, Jerusalem

Conventional roentgenograms provide little information regarding the hip joint in early infancy, as the main components of the joint in the infant are radiolucent cartilage. At the age of about six months, when a small bony nucleus appears in the center of the large radiolucent femoral head, diagnosis becomes simpler.

"Push-and-pull" roentgenograms aid in making more obvious congenital subluxation of the hip joint in infants. By this method, the x-ray is made while one of the infant's thighs is grasped and pulled firmly downward at the same time that the other thigh is pushed upward. When this method was used, a radiolucent oval shadow was noticed on the roentgenogram, lying over the head of the femur of the extremity undergoing traction. The shadow was well defined; it was crescentic in outline and was interposed between the femoral head and the acetabulum in such a way that it demarcated the joint space. This observation led us to study whether this phenomenon could be reproduced regularly and whether it could provide additional diagnostic information in lesions of the hip joint.

Demonstration of the potential articular joint space by manipulation or traction has attracted little attention and has not been extensively discussed in the literature. Fick, in 1910, was the first to report that by hyperextension of some joints he could demonstrate a radiolucent shadow which was consistent with the potential joint space. In 1932 Dittmar reported that he could occasionally demonstrate the medial articular space of the knee in children by forced abduction at the joint. He could not demonstrate this in adults unless there was a concomitant pathological condition.

Widman and Stecher in 1936 were able to demonstrate roentgenographically the potential articular space of the shoulder and knee joints in both children and adults. In 1937, Magnusson reported that the joint space could be demonstrated only in the shoulder, knee, and metacarpophalangeal joints. He assumed that separation of the cartilaginous joint surfaces created a "gas chamber" which was radiolucent. Nordheim, in 1938, reported that he could demonstrate the medial joint fissure in normal subjects by forceful abduction at the knee joint. Krogdahl, in 1940, was able to report that he had found Nordheim's technique helpful in diagnosing lesions of the medial meniscus. None of

FIG. 1

Normal hip joints of a newborn infant. The cartilaginous articular margins of the acetabulum and the femoral head are sharply defined. The radiolucent shadow is crescentic.

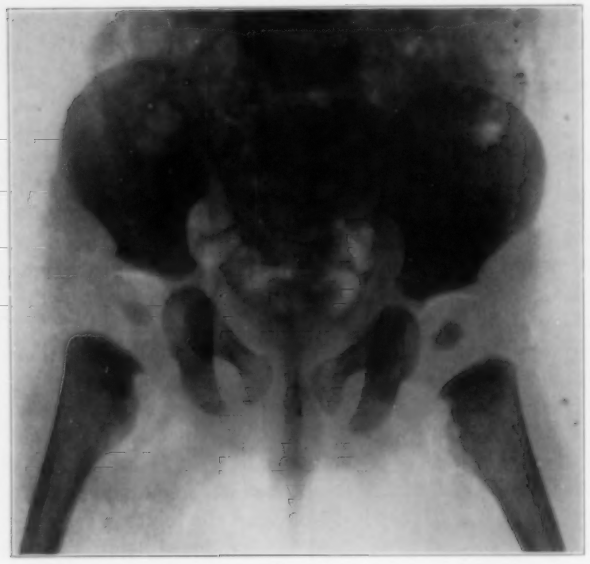


FIG. 2

Normal hip joint in a child one year old. The cartilaginous margins of the joint are sharply defined by a crescentic shadow.

FIG. 3

Delayed ossification of the left femoral head resulting from osteochondritis in a two-year-old child. The radiolucent shadow defines a flattened, bulbous femoral head.

these authors reported visualization of the hip-joint space. In 1940 Evans made the chance observation that he was able to visualize the hip-joint space in a child who had to be forcibly restrained at the time of the roentgenographic exposure. In 1950 Fuiks and Grayson reported spontaneous visualization of the hip-joint space in hips of normal children, when the femur was abducted and externally rotated.

In order to obtain roentgenographic visualization of the articular space of the hip joint, the cartilaginous surfaces must be separated at the moment of exposure. The child is placed on a cassette and the tube is centered over the symphysis pubis in such a way that both hip joints are exposed simultaneously. An assistant firmly clasps the infant's chest with both hands and the physician holds both lower limbs above the knee. While the extremities are in external rotation, he continues traction for a few seconds before the exposure is made. With this method a well defined radiolucent crescentic shadow, interposed between the acetabulum and the femoral head, is shown (Figs. 1 and 2).

A group of forty-eight normal children under the age of three years was examined. Of the infants below the age of six months a positive arthrogram was obtained in 70 per cent. In the group aged six months to two years, the arthrogram was positive in only 30 per cent., while in the group aged over two years the number of positive arthrograms was negligible. It would appear from this that, as the age of the children increased, the chances of obtaining a successful arthrogram were reduced.

A traction arthrogram defines the cartilaginous surfaces of the joint. In cases in which development of the capital femoral epiphysis is retarded, either because of immaturity or because of pathological delay of ossification, this method is of particular value. In

FIG. 4

Bilateral osteochondritis of the femoral head. The traction arthrogram defines the cartilaginous outlines of the capital epiphyses, which are flattened.

cases of osteochondritis, it was noted that the normal crescentic outline of the femoral head had a more flattened appearance (Figs. 3 and 4). The similarity of this finding to that of flattening of the femoral head in early cases of Legg-Perthes disease is quite striking. Positive arthrograms in cases of congenital subluxation of the hip joint could not be obtained. Traction arthrography of the hip joint has a limited field of application and, unlike arthrography with contrast media, it does not define the anatomical details of the joint. It has many advantages, however: No intra-articular injection of foreign material is required and there is no need of anaesthesia or hospitalization. It is hoped that, with improvement in technique, the reliability of traction arthrography as a diagnostic aid will be increased.

REFERENCES

DITTMAR, OTTO: Der Kniegelenks-Meniskus im Röntgenbilde. Röntgenpraxis, **4**: 422–445, 1932.

EVANS, W. A., JR.: The Roentgenological Demonstration of the True Articular Space. With Particular Reference to the Knee Joint and the Internal Semilunar Cartilage. Am J. Roentgenol., **43**: 860–864, 1940.

FICK, RUDOLF: Handbuch der Anatomie und Mechanik der Gelenke. Teil II, S. 53. Jena, Gustav Fischer, 1910.

FUIKS, D. M., and GRAYSON, C. E.: Vacuum Pneumarthrography and the Spontaneous Occurrence of Gas in the Joint Space. J. Bone and Joint Surg., **32-A**: 933–938, Oct. 1950.

KROGDAHL, TRYGVE: Röntgenologische Diagnose der Meniskusluxation im Kniegelenk ohne Verwendung von Kontrastmitteln. Acta Radiol., **21**: 335–342, 1940.

MAGNUSSON, W.: Über die Bedingung des Hervortretens der wirklichen Gelenkspalte auf dem Röntgenbilde. Acta Radiol., **18**: 733–741, 1937.

NORDHEIM, YNGVE: Eine neue Methode, den Gelenkknorpel, besonders die Kniegelenkmenisken, röntgenologisch darzustellen (ohne Zuhilfenahme eingespritzten Kontrastmittles). Fortschr. a. d. Geb. d. Röntgenstr., **57**: 479–495, 1938.

WIDMANN, B. P., and STECHER, W. R.: Roentgenographic Demonstration of the True Articular Space. Radiology, **27**: 541–544, 1936.

SPONTANEOUS RUPTURE OF THE EXTENSOR POLLICIS LONGUS TENDON FOLLOWING THE FRACTURE OF THE CARPAL NAVICULAR BONE

BY JACK LEVINE, M.D., AND MONROE SCHNEIDER, M.D., BROOKLYN, NEW YORK

Rupture of tendons from constant friction over roughened bone is a recognized complication of the healing of certain fractures. Spontaneous rupture of the extensor pollicis longus tendon from friction over the roughened lower end of the radius following healing of a Colles fracture is a classic example of this phenomenon. However, rupture of the same tendon more distally at the site of fracture of a navicular bone has never been reported to our knowledge. This unusual occurrence seems worthy of being reported.

H. K., twenty-five years old, in a fall of twenty-five feet down an elevator shaft, sustained a dislocation of the left lunate bone and a fracture of the left navicular and cuneiform bones on April 10, 1950 (Figs. 1-A and 1-B). He also incurred an impacted fracture of the head of the left radius. The dislocation of the lunate was reduced on April 12, and an above-the-elbow cast was applied. This was changed to a below-the-elbow cast on April 20. On May 3, as the oedema had subsided, making the cast loose, a new cast was applied. Plaster immobilization was continued until October 20, 1950, because of the slow healing of the navicular bone. Following removal of the cast (Figs. 2-A and 2-B), a satisfactory range of painless motion was obtained, as follows: 30 degrees of dorsiflexion, 45 degrees of palmar flexion, 20 degrees of ulnar deviation, 10 degrees of radial deviation.

The patient was able to resume his regular work as a butcher and had no difficulty referable to his wrist until February 8, 1951, when, while tying a bundle, he suddenly felt a snap in the back of his left wrist and

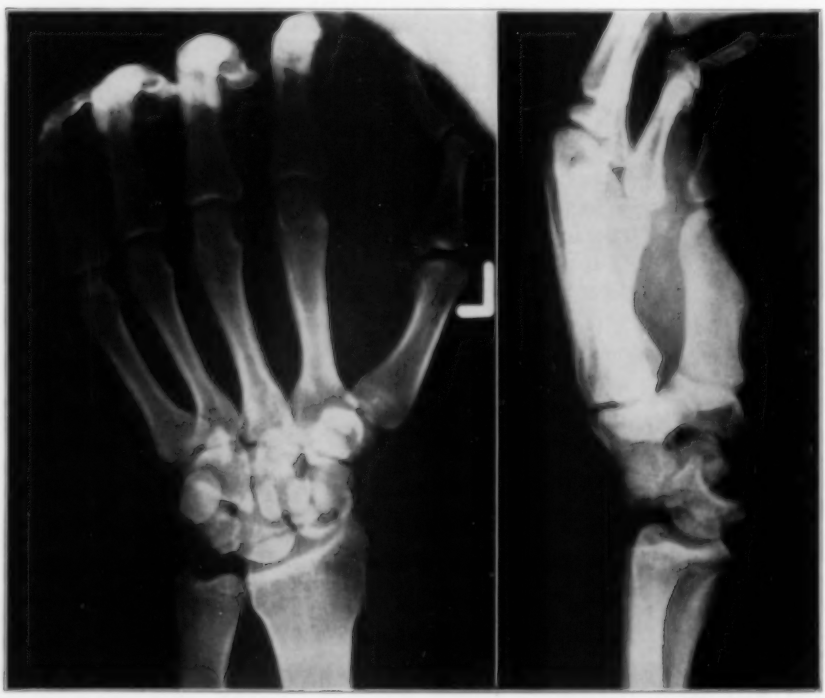


FIG. 1-A

FIG. 1-B

Fig. 1-A: Anteroposterior and lateral views of the left wrist made April 10, 1950, demonstrated the dislocation of the lunate bone and fractures of the navicular and cuneiform bones.

Fig. 1-B: Lateral view of the left wrist made April 10, 1950.

FIG. 2-A FIG. 2-B

Two views of the left wrist made June 22, 1951.

The fracture was well healed. The thin fragment of bone seen on the dorsum of the wrist in the lateral view was a fragment of the cuneiform bone and did not play a role in the rupture of the extensor pollicis longus tendon.

lost the ability to extend his thumb. Examination revealed a rupture of the extensor pollicis longus tendon.

At surgery, the extensor pollicis longus tendon was found to be frayed over a distance of almost four centimeters and was ruptured in the middle of this frayed area. The point of rupture lay directly over the navicular bone, which showed increased prominence posteriorly. The most badly frayed portion of the tendon, about 2.5 centimeters, was excised. The tendon ends were then brought out over the dorsal carpal ligament and an end-to-end suture was performed. It was necessary to keep the wrist and thumb extended to avoid tension on the suture line. The postoperative course was uneventful. The cast was removed after three weeks and active exercise was instituted. One month later, the patient had regained full use of the thumb.

At the most recent examination, May 10, 1954, the patient had no symptoms referable to the tendon rupture.

This case is of interest because it demonstrates an unusual instance of the susceptibility of tendons to attrition from constant friction over roughened bone.

DISCUSSION

FURTHER EXPERIENCE WITH EXTRA-ARTICULAR ARTHRODESIS OF THE SUBTALAR JOINT

(*Continued from page 259*)

formity by heel-cord lengthening. We have lengthened the heel cords in several patients who had cerebral palsy, but discussion of that group of patients was not included in the presentation.

Finally, I would like to point out that a foot with a little bit of eversion can be a good weight-bearing foot; whereas a foot with varus deformity can cause considerable difficulty, particularly if there is some element of equinus deformity present. Care must be exercised in performing the extra-articular subtalar arthrodesis that overcorrection of the foot deformity is avoided. If the foot is held in an overcorrected position, varus deformity will result. In this series, we have had to revise two feet which were in too much varus deformity.

THE ONE-BONE FOREARM

A Reconstructive Procedure

BY R. A. MURRAY, M.D., TEMPLE, TEXAS

From the Department of Orthopaedic Surgery of the Scott and White Clinic, Temple

Rarely is one justified in not attempting to restore pronation and supination of the forearm if these motions are severely limited. Infrequently, however, if there is instability, with pain and loss of strength, associated with limited rotation, all rotation may be justifiably sacrificed to restore a stable, painless lever on which the hand can function.

Excision of the radial head or of the distal part of the ulna, when indicated, allows increased rotation with no loss of function. Removal of too much of the proximal end of the shaft of the radius with the head, or of too much of the distal part of the ulna will leave a weak forearm in which there may be some migration of one bone on the other and poor function. If the articulating ends of either bone are present but there is loss of shaft it is usually possible to bridge the gap and restore function by a properly executed bone graft. When there is massive loss of bone associated with loss of the articulating joint surface, it may be technically impossible to place a graft in such an area and to restore a stable, painless arm with good function. It is in this type of patient that the simple procedure of producing a one-bone forearm is indicated. Ideally, the proximal humero-ulnar and distal radiocarpal joints should be present and functioning.

TECHNIQUE

The actual surgical procedure may be accomplished by step-cutting of the bone ends and the use of an intramedullary nail through the proximal end of the ulna into the distal

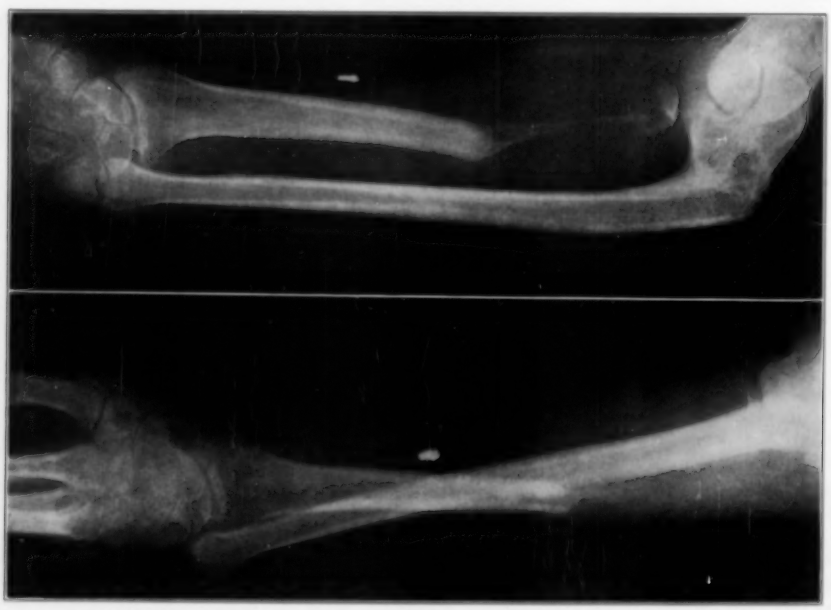


Fig. 1-A

Case 1. Preoperative roentgenogram.

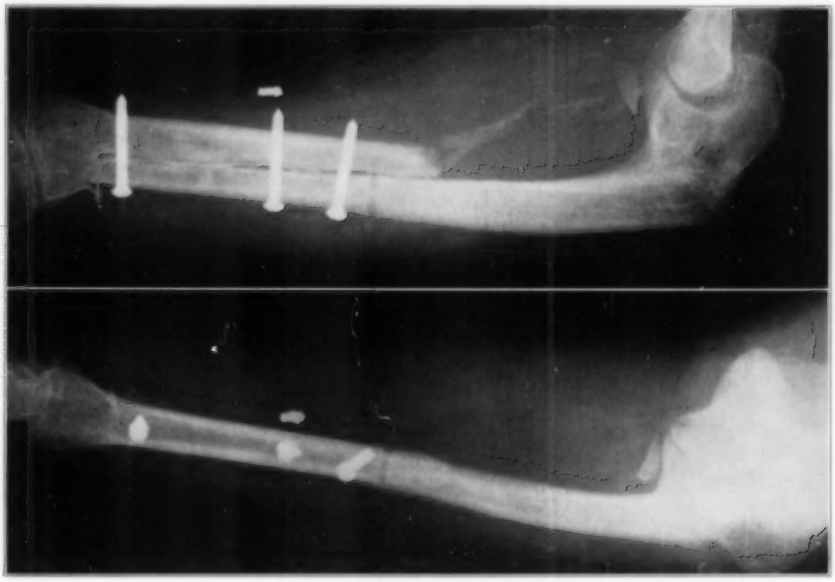


FIG. 1-B
Roentgenograms made after operation.

end of the radius for immobilization. Usually, sufficient bone is present and an alternate method may be excision of adjacent surfaces of the radius and ulna and side-to-side fixation with cross screws. Plaster-cast immobilization is necessary until bony union has occurred. Selection of the desired permanent position should follow a trial period during which the arm is placed in a cast in varied degrees of rotation. A position from pronation to mid-position, supination being avoided, is usually the best functional position.

Two patients have been treated by construction of a one-bone forearm.

CASE 1. A twenty-year-old soldier was seen several months after he had received a severe gunshot wound in the left forearm during World War II. A large granulating wound was present over the dorsoradial surface of the upper part of the forearm. A radial-nerve palsy was associated with the loss of bone in the radius and malunion of the ulna (Fig. 1-A).

Reconstruction of the arm first required application of an abdominal pedicle to cover the granulating wound. Because of the malunion of the ulna and deep scarring in the soft tissue, rotation of the forearm could not be restored; hence, replacement of the proximal part of the radius was not justifiable. Surgical fusion of the distal radial fragment to the ulna resulted in a stable forearm (Fig. 1-B). The usual tendon transfer for radial palsy was accomplished. The flexor carpi radialis was transferred to the long extensors of the thumb and index finger; the flexor carpi ulnaris was transferred to the finger extensors; the pronator teres, to the radial dorsiflexors; and the palmaris longus, to the abductor pollicis longus.

FIG. 1-C
Photograph showing the early result.

Figure 1-C indicates the function present during early convalescence. The patient was advised to use the forearm for a period of time before correction of the malunion of the ulna was undertaken to improve elbow motion. Although this

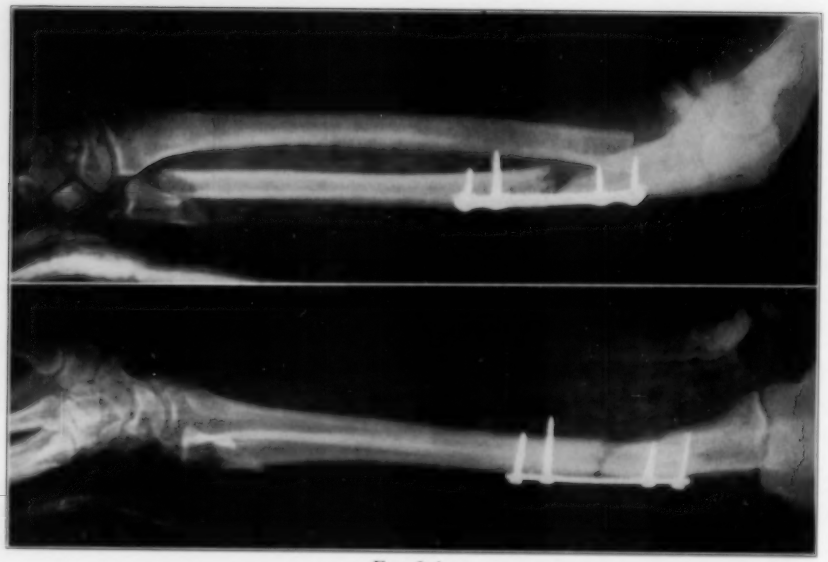


FIG. 2-A
Case 2. Preoperative roentgenograms.

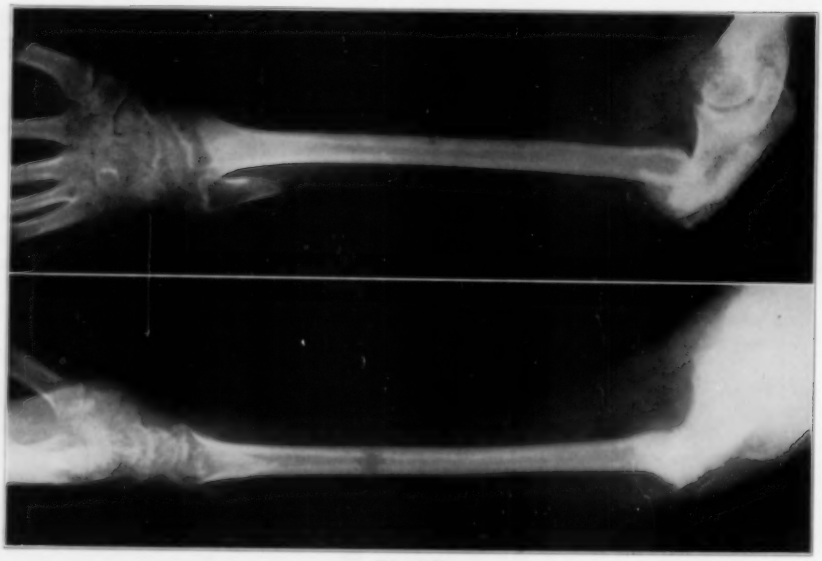


FIG. 2-B
Roentgenograms made after excision of the sequestrated ulnar shaft.

patient has been lost to further follow-up, his functional result, when he was last seen, was satisfactory.

CASE 2. A white man, thirty-four years of age, was admitted to the Orthopaedic Service several days after an automobile accident in which he suffered severe trauma to his left forearm. Preliminary care had been administered; but, because of associated injuries and elevated temperature, he was quite ill.

The full-length cast was immediately removed and the injured limb was inspected. (Figure 2-A illustrates the damage to bone.) The radial head had been resected and a plate had been applied to the fracture of the proximal end of the ulna. The fracture of the distal end of the ulna was still unreduced. The soft tissue on the entire ulnar surface of the forearm between the two fractures was necrotic. It had been sutured. The gangrenous

FIG. 2-C

FIG. 2-D

Figs. 2-C and 2-D: Roentgenograms showing the end result.

elements included skin, subcutaneous tissue, and the muscle down to and surrounding the ulna. The ulnar shaft was a sequestrum. There was no evidence of infection.

All devitalized tissue and the sequestrated portion of the ulna were excised. After ten days, the entire soft-tissue wound was covered by a split-skin graft. For a better cosmetic result, and to allow further reconstruction, an abdominal pedicle was applied after eight weeks.

During this treatment, an attempt was made to maintain the position of the forearm with a cast. The radial head drifted into contact with the proximal ulnar fragment, however, and cross-union resulted (Fig. 2-B). Although our primary aim of a stable one-bone forearm had thus been achieved spontaneously, the position was improved by an osteotomy at the site of union and insertion of a Knowles pin for intramedullary fixation. Figures 2-C, 2-D, and 2-E illustrate the final result.

An interesting result was secured by tendon transplantation. Because of the actual loss of both the profundus and the sublimis flexor muscles at the time of his primary injury, the patient had lost all finger flexion. Good intrinsic function had been maintained, however. A tendon transfer of the flexor carpi radialis to the flexor profundus tendons above the wrist resulted in complete finger flexion (Fig. 2-F).

This patient's functional result was excellent. He had good wrist and elbow motion. Although some weakness in flexion of his fingers was present, actual use of the extremity was very satisfactory.

SUMMARY

The construction of a one-bone forearm by cross-union of the proximal part of the ulna and the distal end of the radius should be considered when instability and extensive

FIG. 2-E
Photograph showing the functional end result.

FIG. 2-F
Photographs showing function of the hand after tendon transfer.

loss of the distal part of the ulna or the proximal part of the radius are present. The procedure is indicated only if the instability and bone loss are irreparable by bone-grafting or other reconstructive procedures and there is no chance of restoring rotation of the forearm.

NOTE: A movie concerning Case 2 was presented at The American Academy of Orthopaedic Surgeons, Chicago, Illinois, January 24, 1953. This film is on loan from the Academy Film Library.

THE ATTITUDE OF THE PHYSICIAN TOWARD REHABILITATION *

BY A. R. SHANDS, JR., M.D., WILMINGTON, DELAWARE
Alfred I. duPont Institute of the Nemours Foundation

Every physician is basically interested in his patient's getting well; otherwise, he would not be in the practice of medicine. But, how many physicians are really giving serious thought to the full significance of a sick person's recovery and what should be done beyond medical care? In most countries of the world this number is small. Rehabilitation in its fullest interpretation is the complete process of getting well. It starts with the onset of the illness or the accident and continues to the time when the patient is restored to normal living, or as near normal living as is possible with the abilities remaining after accident or illness. The attitude of the medical profession in the United States toward this complete process of recovery varies a great deal; it depends largely on the concept which the individual physician has in rendering service to his patients.

Some doctors have little conception of what is meant by a program of rehabilitation beyond medical care. This segment of our profession is usually interested only in the first stage of rehabilitation, — namely, the treatment of the specific complaint which brings the patient to the doctor; they constitute perhaps 30 per cent. of practitioners. These physicians might be called the *Tolerant-Attitude Group*. They are not opposed to subsequent stages of rehabilitation for their patients, but, knowing so little about a program, they are not interested in assisting in the activities of the patient in getting well beyond what is necessary to heal the wound or cure the illness. Hence, they are only onlookers in any part of a rehabilitation program which extends beyond their own self-limited medical practice.

The second group, probably the largest, is composed of those physicians who know something more should be done for their patients beyond medical care, but they definitely do not want to be burdened with the responsibility for its accomplishment. They are perfectly willing to let others take over, prescribe, and do the job. They constitute easily 50 per cent. of all practitioners. This group might be termed the *Passive-Attitude Group*. In defence of these two groups it should be stated that 90 per cent. of most practising physicians in the United States are so busy examining and treating the patients they are required to see in office, home, clinic, and hospital that there is little time to think about or plan for further patient care. Moreover, many of these two groups, having given little thought to what is involved, do not appreciate the real value to their patients of prescribed activity beyond medical therapy.

The third group, some of whom may be specialists, is made up of those who have an interest in rehabilitation. They would like to learn and do more, but they have never been shown how they can participate. Only occasionally do these doctors furnish intelligent help and advice to their patients after medical care. They constitute probably 15 per cent. of all practitioners. This group should be called the *Interested-Attitude Group*. With interpretation, stimulation, and guidance these physicians could be definitely brought into programs as active, enthusiastic participants. However, they not only must be shown but must be led. Unfortunately, good and able leadership for this group is not always available. Occasionally, upon the request of a hospital board or a community planning committee, one of these physicians will visit a well established Rehabilitation Center to learn what is being done and, upon his return, will become interested in starting a program. This is the group to whom more attention should be paid by those who are working in the field. Great good for the cause will follow when these physicians can be brought actively into total rehabilitation programs.

* Presented by invitation at the Sixth World Congress of the International Society for the Welfare of Cripples, The Hague, The Netherlands, September 13, 1954.

Those physicians who are deeply interested in, and definitely appreciate the tremendous social and economic value of, rehabilitation programs in hospitals and communities form the fourth group. Their number is small and will constitute certainly not more than 3 per cent. of the total practitioners. They will always assume responsibility for participating in programs planned to carry the patient through all stages of recovery to normal living. However, they are usually successful practising physicians who cannot always divorce themselves sufficiently from their routine work to devote more time to rehabilitation, although they fully realize its importance. About 25 per cent. of the orthopaedists fall in this group. This is the *Enthusiastic-Attitude Group*. They form an excellent nucleus to call on for promotion and membership on advisory and planning boards of rehabilitation programs.

The fifth and last group are those who are specialists in the field of physical medicine, the physiatrists. They form only a fraction of one per cent. of the total practitioners. This small group has been doing a magnificent job in some communities in showing the public and the profession what can be done. However, the efforts of this group have been more successful in convincing citizens' committees, hospital administrators, and lay medical boards of the worth of good rehabilitation programs than they have in convincing their fellow physicians. This has been unfortunate, for the complete success of any medical program requires physician support.

With the apathetic attitude today of 80 per cent. or more of the medical profession toward rehabilitation, it is very evident that something must be done if we are to move ahead in this field. This present situation has not always existed. In the past, when the tempo of living was slower and the family physician was an "institution", medicine on the whole was more interested in restoring the patient to normal living than in modern times. There is no doubt that the old family doctor knew and practised total rehabilitation in his daily work. He had every interest of his patient at heart; he was called on for advice by the patient and the family for things other than curing the physical ills. He was a psychologist, a vocational counselor, a "father confessor", and everything else to the patient, which would be necessary for restoration to normal living. What we really need today is to develop among physicians the philosophy of restoring the patient to normal living which was part of the life of the family physician of the past.

In order to increase rehabilitation services, physicians and more physicians must become, not only more interested, but also active participants in this type of work. Every practitioner must be convinced that it is his responsibility to direct the rehabilitation programs for his patients after medical care. How this can be done is the most vital and serious question we have to face today in this field of medicine. Rehabilitation is something which actively touches, and is part of, every branch of medicine. It should be thought of by every practising physician as a necessity in the treatment of patients; even more so than the necessity of having roentgenographic and laboratory examinations in diagnosis and therapy. Bringing more physicians into the work is an undertaking so large that it cannot be left only to the specialists in physical medicine who have been largely responsible for directing this activity in the last decade. The leaders in every department of medicine must become involved.

Some have said that one of the many reasons that rehabilitation has not moved ahead faster and interested more physicians is that, since World War II, it has been associated in name with physical medicine. In the minds of many physicians, particularly in the Passive and Tolerant Attitude Groups, there is an idea that, because of this association, physical medicine and rehabilitation are one and the same thing. Furthermore, many still believe that rehabilitation involves primarily the use of the agents—heat, light, electricity, water, and exercise—which form the basis of physical therapy. Physical medicine is in reality, as we all know, only one of many parts of rehabilitation. The joining up of these two branches of medicine came about as a "marriage of convenience" after the

last War. Due to the extensive and excellent programs of rehabilitation in the Armed Forces, there were, at that time, hard and distinct growing pains in this field of medicine in both civilian and military practice. However, the physicians limiting their work to rehabilitation were few and, in reality, rehabilitation was a medical stepchild with no allegiance. Rehabilitation then was not ready to stand on its own feet and have an independent position, so physical medicine "took it under its wing". In the last ten years, physical medicine has done all it could to develop better services and more interest in rehabilitation. This specialty is to be thanked sincerely by the whole medical profession for "fathering" and "nursing" a part of medicine which belongs to every practising physician. The time has come when, if rehabilitation is to progress as it should, something else must be done and this is what your speaker wishes to discuss with you next.

The first thing which should be considered is a meeting of the best minds we have from all fields of medicine to discuss the problem of rehabilitation from the viewpoint of (1) rendering better service to the patient, (2) full participation in rehabilitation programs by all physicians, and (3) giving the specialty an independent status in medical practice. Strong leaders from all fields, such as internal medicine, general surgery, orthopaedic surgery, psychiatry, neurology, tuberculosis, and general practice, are necessary for these discussions. Out of such a meeting should come, on a national level, a Rehabilitation Council of Physicians representing all branches of medicine most concerned with this work. This Council should determine policies for the profession and should ask the physicians in each field of medicine to take the responsibility for incorporating good and better programs of rehabilitation in their teachings and practices. It should promote joint cooperative programs in every community. It is my feeling that never will the proper interest be stimulated among doctors and the attitude of the average physician be changed until this or a similar type of approach is made. A conference leading to a Rehabilitation Council of Physicians should be called in every country by the present leaders in the field of rehabilitation.

The time was never more opportune in the world than it is today for such action. In many countries, increasingly large sums of money are being made available to establish new rehabilitation centers and for increasing rehabilitation services. In every part of the world there is a marked reawakening of interest in all problems of rehabilitation. It is the sincere hope of your speaker that a recommendation may come out of this Sixth World Congress of the International Society for the Welfare of Cripples which will lead to such conferences.

To carry out this suggestion on a world-wide basis, I propose that this Medical Section of the International Society for the Welfare of Cripples which is meeting here today become a permanent body of the Society. Such a group could well consist of representatives of the various fields of medicine, including the auxiliary services which are essential to a good rehabilitation program. I hope that this Medical Section can meet again at the next World Congress and that we will be able to report that substantial action has been taken in our various countries.

The betterment in medical service which can follow such an action is unlimited. If we continue as we are today, the progress will continue to be very slow, as it has been in the past. We who are deeply interested in this field must plan a program which will more rapidly broaden the interest of the medical profession and increase the number of active participants in this work, so that in the future there will no longer be physicians whose rehabilitation attitudes are *Passive*, *Tolerant*, and *Interested*, but all will be actively engaged in this great cause and be definitely of the *Enthusiastic-Attitude Group*.

REFLECTIONS ON SOME INTERESTING PERSONALITIES IN ORTHOPAEDIC SURGERY DURING THE FIRST QUARTER OF THE CENTURY*

BY LEO MAYER, M.D., NEW YORK, N. Y.

When I was graduated from medical school in 1909 our orthopaedic journal, then known as *The American Journal of Orthopaedic Surgery*, which had been founded to replace the *Transactions of The American Orthopaedic Association*, was barely seven years old. Consequently, my medical life has had an almost equal coexistence with our *Journal*, and I have been one of the few orthopaedic surgeons still living who have been privileged to witness and in a modest way to participate in one of the most dramatic developments of modern medicine,—the evolution of orthopaedic surgery from the strap-and-buckle phase to its present proud position as a major surgical specialty.

First, let me undeceive those among you who may think that, because of the appellation "strap-and-buckle period", good surgery was non-existent during the late years of the nineteenth and the early years of the twentieth century. Bradford, in Boston, as early as 1895 operated successfully for recurrent dislocation of the patella. DeForest Willard, the father of our fellow member, performed as many as six osteotomies at one sitting to correct rachitic deformities, and such was his skill that the patients' crooked legs were made straight. Lewis A. Sayre, the father of Reginald, was one of the first surgeons in America to resect a hip joint; that was in 1854 when he was only thirty-four years old. In 1893, Reginald corrected a club hand due to absence of the radius by shifting the ulna to the middle of the carpus, an operation which only a few modern orthopaedic surgeons have coped with successfully. Dr. Harry Sherman of San Francisco was by all accounts a brilliant surgeon; it was he who had the audacity to advocate early operation on tuberculous knees and hips, and he secured good results, particularly in the knee operations, where a fusion occurred. Arthur J. Gillette of St. Paul, Minnesota, and Gwilym G. Davis of Philadelphia were equally courageous and skillful in operations on ununited femoral necks; they freshened the bone ends and maintained good apposition by the insertion of ivory pegs, nails, or screws. Remember that these men worked without the benefit of an x-ray department, without blood transfusions, with imperfect anaesthetics—and you will have some concept of their speed and dexterity and their respect for tissues.

In contrast to these outstanding surgeons, there were many high-ranking orthopaedic specialists who never entered the operating room except to apply a plaster-of-Paris dressing or, occasionally, to perform a subcutaneous tenotomy. One of these was Newton M. Shaffer who, with Virgil P. Gibney, organized our Association in January 1887. Shaffer literally besought his orthopaedic colleagues to specialize in mechanical therapy. He felt that to mingle surgery and mechanics was to endanger both. Gibney himself, the first chairman of The American Orthopaedic Association—and my own teacher of orthopaedic surgery at the Columbia University College of Physicians and Surgeons—was not a trained surgeon but, unlike Shaffer, he foresaw the surgical trend of twentieth-century orthopaedics. As early as 1891 he predicted that orthopaedic surgery would include the treatment of fractures and, above all, the correction of malunited fractures. It was also Gibney who extended orthopaedic treatment to adults by opening an adult ward in 1903 at the Hospital for the Ruptured and Crippled, now the Hospital for Special Surgery. In Boston, Dr. Robert Lovett, the John Ball and Buckminster Brown Professor of Orthopaedic Surgery at Harvard Medical School, was no surgeon, but his pathological studies, his research into the mechanics of scoliosis, his brilliant teaching, and his organization of the Harvard Infantile Paralysis Commission have won him a high place in our society.

* Read at the Annual Meeting of The American Orthopaedic Association, Bretton Woods, New Hampshire, June 11, 1954.

As one thinks of orthopaedic leaders such as these, it is only fair to conclude that orthopaedic surgery at the turn of the century did not demand surgical skill and knowledge as a prerequisite. The change in emphasis from mechanics to surgery has been one of the noteworthy advances of our specialty. Let no one gain the impression that this transition was easy and peaceful. Inevitably it precipitated a clash with the general surgeon, who disputed the new surgical claims of the young specialty. According to A. M. Phelps, the conflict was not new. "The orthopaedist was always at war with the general surgeon," he wrote in his Presidential Address in 1894. "There never was a time when they could lie peacefully together in the same bed, excepting like the lion and the lamb—one inside the other, and the poor *orthopede* was always inside."

Meanwhile, what was happening on the Continent? Germany and Austria were looked up to as the leaders in medicine; great pathologists like Rokitansky and Virchow, bacteriologists like Robert Koch, Klebs, Loeffler, and Neisser, and chemists like Ehrlich had built a firm scientific foundation for clinical medicine. In orthopaedic surgery, too, Hoffa in Berlin, Lorenz in Vienna, and Lange in Munich had achieved international reputation. Lorenz and Lange had been guest speakers at meetings of The American Orthopaedic Association. Therefore, it was but natural when, in 1912, I had decided to study orthopaedic surgery, that I turned my steps toward the *Koenigliche orthopädische Poliklinik* in Munich, which offered unexcelled clinical opportunities under Lange and free scope for pathology and research in the pathological department under Prof. M. Borst.

Lange was a great teacher, to whom I am indebted for training in the orthopaedic fundamentals. He was a most industrious worker; in fact he was so immersed in his profession that he had no time for outside interests. His daily program expressed this single-hearted purpose. He rose at five in the morning and was joined half an hour later by his faithful, long-suffering secretary to whom he dictated for two hours. This he considered his best working period, and during these hours he formulated his numerous scientific papers. At eight, as the clock struck the hour, with the same regularity shown by Royal Whitman in his attendance at the Hospital for the Ruptured and Crippled, he appeared in the *Koenigliche orthopädische Poliklinik, Pettenkoferstrasse*, where, after rounds, he examined the new patients, outlined their therapeutic programs, and then operated. Since the modern orthopaedic operating table had not been invented, Lange had devised his own strange-looking apparatus for applying plaster-of-Paris dressings. This consisted of a heavy gas-pipe frame, about seven feet long and five feet wide, resting on four legs. Stout webbing straps could be placed at the desired intervals to support the trunk and extremities of the patient who was transferred after operation from the conventional table to the frame. I still have a vivid recollection of Prof. Lange, attired in his huge plaster apron and boots, climbing over the rail of his frame in order to hold the legs of the patient, while his three assistants, with the *Amerikanischer Voluntär* acting as an awkward fifth wheel of the wagon, applied the plaster dressing. A "Lange plaster" never broke, for it was applied with Teutonic thoroughness and re-enforced at every joint. I need say nothing of its weight and the difficulty his assistants had in removing one of these massive creations. After lunch Lange, like Winston Churchill, took to his bed for a two-hour sleep. From four until suppertime he saw his private patients. In the evening he read; lights out at ten o'clock. Over the week end he retired to his villa at Bad Tölz in the Bavarian Alps. There in his garden he had built himself a reading bunk, not unlike Bernard Shaw's at Ayot St. Lawrence, except that it did not revolve but always looked toward the mountains. Here, all by himself, he read for hours on end.

After the lapse of many years it is not too difficult to appraise Lange's contributions. He was the first surgeon to conceive of an internal splint for Pott's disease. True, the method, consisting in the implantation of two metal rods firmly bound to the spinous processes, did not succeed, for it was quite unphysiological; but it pointed the way to the

FIG. 1
Dr. Fritz Lange

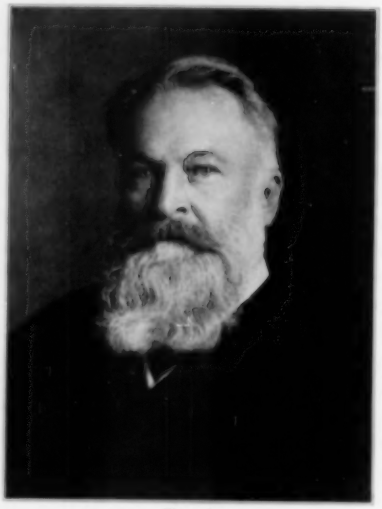


FIG. 2
Dr. Adolf Lorenz

bone-grafting operations of Albee and Hibbs which, a few years later, revolutionized spine surgery. He was also the first Continental surgeon to revolt against the Lorenz "frog position" for congenital dislocation of the hip. He utilized the internal-rotation-abduction position, because he considered it more physiological. He never employed the open operation. When a hip resisted manual reduction, he used the Bradford table with its mechanical lever,—a method which he had learned on his trip to Boston early in the century. In his later years, following an intensive follow-up study similar to Bruce Gill's, he conceded that, despite his care in reduction and fixation, almost all of his cases of congenital dislocation of the hip evidenced extensive arthritic changes. He was best known for his tendon operations. In these he utilized strands of heavy silk soaked in paraffin to prolong the tendon until it reached an appropriate bony insertion. Although the method unquestionably helped to stabilize many paralyzed limbs, Lange himself admitted that these artificial tendons did not glide, and it was at his instigation that Carl Henze of New Haven and I started our experiments which resulted in the confirmation of Biesalski's intrasheath technique and the development of the physiological method of tendon transplantation. As an orthopaedic leader Lange was important, not because his own operations have withstood the test of time, but because he was unwilling to rest content with old methods; and, in the important fields of tuberculosis, congenital dislocation of the hip, and paralytic deformities, he made valiant attempts to improve our operative therapy.

In Berlin, Hoffa, who had dominated orthopaedic surgery at the turn of the century, had been replaced by the scholarly but ineffective Joachimsthal. When I reached Berlin in 1913, all of the operations on bones and joints at the *Charité* were being assigned to the general surgeons. Even scoliosis was assigned to a general surgeon by the name of Klapp who had evolved the so-called "creeping corrective method". The orthopaedic department was permitted the privilege of performing subcutaneous tenotomies. Consequently, I attached myself to Prof. Konrad Biesalski, whose work on tendons fascinated me. Biesalski had had inadequate surgical training, but he had an open, fertile mind. He had established a large hospital for crippled children with ample clinical material, and it was he who first emphasized rehabilitation as an important phase of orthopaedic activity. Together we performed a series of Foerster operations and Stoffel neurectomies for cerebral palsy, in order to compare the results with tenotomies; we did a number of bone-grafting operations and developed a system of physiological tendon transplantations.

With the outbreak of the First World War, Biesalski busied himself almost exclusively with the rehabilitation of war wounded. The crippled children's hospital, known as the *Oskar-Helene Heim*, became the first rehabilitation center in Europe, antedating even Sir Robert Jones's rehabilitation center at Shepherd's Bush. Biesalski had two able assistants in this work: a brilliant brace-maker, one Herr Zeibig who helped him devise clever prostheses and tools for the arm amputees, and his director of education, Herr Hans Wurtz, whose little book *Der Wille Siegt* (The Will Conquers) should be read by everyone interested in helping the handicapped to overcome their disabilities. Biesalski traveled from one orthopaedic center to another throughout Germany, helping his colleagues to develop their orthopaedic skills in this new venture for which he invented the word *Kriegskrüppelfürsorge* (care of the war cripples). Some rehabilitation experts of today have apparently forgotten their indebtedness to this great pioneer.

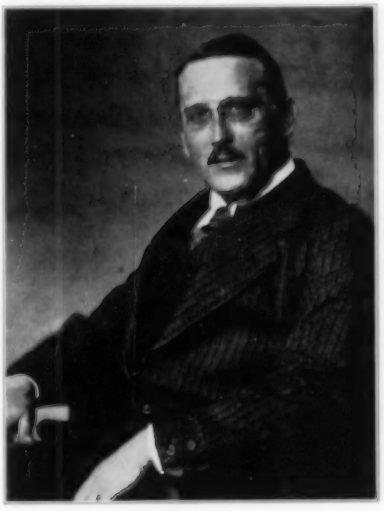


FIG. 3
Prof. Konrad Biesalski

The Vienna clinic of Lorenz (*Orthopädische Universitäts Klinik*) was unquestionably the largest in all Europe. The staff had to treat so many patients that they had to adopt short-cut methods. Tuberculosis of the hip was treated by applying a plaster-of-Paris dressing. If the hip showed an adduction-flexion deformity, it was left in the deformed position and the patient was told to return in a year. By that time, in most cases a fibrous union had formed. The deformity was then corrected by a subcutaneous subtrochanteric osteotomy and a second plaster was applied. When this was removed in six months, the patient was usually ready for discharge. Thus, three visits were the usual routine for tuberculous coxitis. Congenital dislocation of the hip was treated by closed reduction and lengthy fixation in plaster. If anatomical replacement could not be secured, an anterior displacement was considered satisfactory; this corrected the lordosis and improved the gait.

Lorenz himself was an impressive figure: over six feet tall, broad of chest, and strong of arm, with a long flowing beard,—the prototype of the foreign professor. He was most skillful in manipulations, but he was not a trained surgeon. Despite this fact, he invented a most ingenious operation, the bifurcation osteotomy of the femur, which has its place today in our treatment of unstable hips.

A similar operation was perfected at about the same time by Alfred Schanz of Dresden,—the abduction osteotomy. Schanz had no professional title, he had no university or hospital affiliation, but his own private practice was large enough to give him the equivalent of a hospital clinic. He was a dexterous operator who knew his own limitations and never exceeded them. He had invented his own method of reducing congenital dislocation of the hip in children: standing on the side of the patient opposite the dislocated hip, he grasped the thigh just above the knee, gave a sudden adduction jerk combined with an internal-rotation twist, and at the same time pressed the trochanter downward with his other hand. Almost invariably the head slipped into the socket. After a few weeks in plaster-of-Paris, the child was placed in an abduction brace which permitted a little motion. Schanz had an admirable brace shop which he supervised with loving care. His knowledge of braces was accurate and extensive, as shown by his masterly book on this subject. When one of us thinks he has a new idea for a brace I suggest he look up Schanz*; he is likely to find that his own idea is not so "new" as he thought.

* *Handbuch der orthopädischen Technik für Ärzte und Bandagisten*. Bearbeitet von A. Schanz. Jena, Gustav Fischer, 1908.

Probably the best operator among the German orthopaedic surgeons of the day was Stoffel. He had been the assistant of Prof. Vulpius of Heidelberg and with him had written a book on tendon transplantations, which is now completely out-moded. Vulpius, very jealous of his talented young assistant, had tried to squelch him, but Stoffel was not the man to be squelched. He separated from his chief with a bang loud enough to reach every German clinic, settled in Mannheim, not far from Heidelberg, and soon had an enormous practice. His surgical technique, particularly in nerve operations, was faultless. He made special studies of the internal anatomy of the large peripheral nerves for partial neurectomy in spastic paralysis and also for more exact nerve suture. He treated sciatic-nerve pain by division of the appropriate nerve bundles. Remember that this was long before Mixter and Barr had published their paper on herniations of the intervertebral disc.

As a group, however, German orthopaedists, after the outbreak of the First World War, were not experienced surgeons. The great advances in bone surgery had come from the general surgeons—Payr in clinical practice, Axhausen in research. It was the latter, incidentally, who first observed the method of replacement of dead bone of the graft by living bone: he used the term *schleichender Ersatz* which, translated by Phemister as "creeping substitution", has been in general use ever since. Payr's work on arthroplasty paved the way for Baer, Murphy, and other Americans. Lexer's studies on the vascular supply of bone are still regarded as classics. The cineplastic amputation of Sauerbruch, developed at that time, has been the inspiration for Henry Kessler and other modern orthopaedists.

However, Germany, although it excelled in the field of internal medicine, in orthopaedic surgery did not meet the high standard set by some of the Italian schools. Such high standards were particularly to be found at the *Istituto Rizzoli* in Bologna, where Codivilla, who for many years had been the surgeon-in-chief, had been succeeded by Vittorio Putti. Both men were original, daring, skillful surgeons. I did not have a chance to watch Putti at work until the early 1920's, but at the outbreak of World War I he was already performing arthroplasties, femoral lengthenings, bone-grafting operations, and other complicated procedures. Putti had the charm and graciousness of an Italian courtier. His operations were performed with artistry and great deftness. He hated bleeding and did much better work when a tourniquet could be applied. His hospital was very well organized, but in one respect it seemed to me deficient: Putti did every operation himself, and as a consequence his assistants never had the chance of operating under his direction—the method which we in America have found to be the best in teaching surgery. Besides being a great doctor, Putti was an expert in his knowledge of rare books and, like our own Winnett Orr, had amassed a fine collection. He had an unusual faculty for presenting knowledge, and his presentation before The American Orthopaedic Association in 1921 on arthroplasties has been considered one of the best we have ever had.

His greatest contribution was unquestionably in the field of preventive orthopaedics. In northern Italy more children were born with congenital dislocation of the hip than in any other part of the world. Putti set out to remedy this state of affairs. His researches included a thorough study, not only of the pathology of congenital hip dysplasia and dislocation, but of the maternal care of infants. He found that most mothers diapered their babies with the legs close together and that this position favored the extrusion of the femoral heads. To overcome this habit, ingrained by centuries of hallowed custom, he not only wrote numerous articles but gave lectures to doctors and to the laity, explaining the importance of wide abduction of the extremities and emphasizing the necessity for early roentgenographic examination of every infant. As a result, there has been a marked improvement in the attitude of parents, pediatricians, and general practitioners, with a corresponding gain to the babies of northern Italy.

In France, orthopaedic surgery lagged behind. The modern resurgence under Merle

d'Aubigné, Leveuf, and the Judet brothers is all the more remarkable because of the previous slowness of the French schools to utilize surgical methods. In 1914 the French were adept in one phase of orthopaedics,—the conservative treatment of bone and joint tuberculosis. At Berck-Plage, Calot and his rival Calvé cured thousands of patients by the judicious mixture of patience, sunshine, sea air, and plaster fixation. To witness the application of a Calot jacket gave me an artistic thrill: crinoline sheets were prepared in advance, so they would fit the patient to a nicety, and were soaked in plaster cream. They were then bound to the patient by rolled plaster bandages. Then came the exciting period of expectancy, while nurses and doctor waited for the moment of setting. With Gallic enthusiasm they would suddenly shout, "*Il prend—il prend*"—the plaster had set. The patient was encased in a perfect plaster protection, exactly the opposite of Lange's, light, strong, and so molded as to show every contour of the body. It was but natural that such experts in conservative measures should resist the initiation of surgery.

My own introduction to modern orthopaedic surgery was in Liverpool in the spring of 1913. There I met Sir Robert Jones, then plain Bobby Jones, and at once became a convert to his methods. My own words are inadequate to describe this incomparable surgeon, this truly great man and I, therefore, turn to Lord Moynihan who, on the occasion of Sir Robert's seventieth birthday, wrote as follows: "The story of the triumph of Robert Jones as prophet, high priest, and practitioner in orthopaedic surgery makes plain the reason for our deep respect. Our affection for him transcends, if it be possible, our gratitude for his professional worthiness. Few men have ever possessed in so radiant a degree the genius for friendship. No one can be long in his company, none can work with him or play with him, without realising not only the sweet simplicity of his character, but the greatness of his heart. He speaks ill of no man. He seeks and finds good in all things and in all men. He sets an ideal and a standard of action in friendship which all strive to reach when with him. In a long and very intimate friendship I have never heard an unjust criticism, a cruel jibe, or a word of bitter cynicism on his lips. He covers his displeasures or stern disapproval by silence, or a restrained reproof that is often weightier than a torrent of words from others. His personality radiates cheeriness, good temper, and good-will."

FIG. 4

Photograph shows Hugh Owen Thomas of Liverpool (with the hat on and smoking a cigarette), reducing an old dislocation of the shoulder with the aid of his young assistant, Robert Jones.

From Sir Robert I learned how to remove a meniscus; I still practise his incision, his scrupulous "no-touch" method, and I try to imitate his meticulous, atraumatic technique. From him I learned the correction of paralytic calcaneocavus deformity by the ingenious two-stage operation, the correction of hammer-toe by the implantation of the toe extensor into the metatarsal head, the reduction and retention of such fractures as those of Colles and Pott, and the reduction of long-standing shoulder dislocation. He was most ingenious in his use of the Thomas wrench to correct stubborn club feet and in the application of splints to maintain proper position following operation. Most amazing were his operative clinics at the Royal Southern Hospital, when at a single session he usually performed twenty or more operations. He never hurried, but he never wasted a motion, and his organization was so perfect that there was not a moment's delay between cases.

But even more impressive than his surgery was the man himself: kindness and good humor radiated from his presence; friendliness and hospitality were his watchwords. His enormous energy was matched by a boyish love of fun and harmless practical jokes. I well recall a little incident he related with much glee about Royal Whitman for whom, incidentally, he had great respect. It seems that on one occasion Dr. Whitman visited Sir Robert in the famous office at 11 Nelson Street and on the very same morning he was consulted by a New York lady suffering from painful flat feet. Sir Robert sensed the opportunity for a little fun and said to Dr. Whitman, "Maybe you would be kind enough to examine the patient. You know much more about flat feet than I do." Dr. Whitman looked at the lady's feet and said, "An ideal case for the Whitman arch support". Whereupon the lady said, "Dr. Whitman, you evidently don't recognize me. If you're prescribing the same supports you gave me in New York, I'll have none of them."

I have dwelt long and lovingly on Sir Robert Jones, for not only did he exercise the greatest influence in my own personal orthopaedic development but also he unquestionably did more to stimulate our specialty than any other surgeon here or abroad. His influence was felt even more in America than in England, particularly during the years preceding the First World War, when, in the adolescence of our specialty, we were shooting upward so rapidly as to resemble a teen-ager with pants too short for his long legs. Liverpool was the Mecca for the American surgeon anxious to learn. In 1905 Dr. Goldthwait, the oldest living member of our Association, visited Sir Robert and wrote, "I doubt if any personality ever made such a strong impression on me as Sir Robert did at that time." John Ridlon wrote him in 1906, "Everyone here who had any interest in orthopaedics feels that he must spend as much time as possible with you when he goes over". And George Packard wrote him, ". . . nothing interested me like Liverpool". General surgeons such as John Murphy and Will Mayo also sensed his power. Wrote the latter, "Just as Lawson Tait carried sound surgery into the abdomen and Victor Horsley into the cranial cavity, so has Mr. Jones carried sound surgical principles into orthopaedic practice, and rapid cures are the result in a large number of cases which were formerly treated for months and years by orthopaedic apparatus. This does not mean that Mr. Jones has discarded these measures. He is most careful in the after treatment, and uses mechanical contrivances for their proper purposes, as an adjunct to surgery, not in place of it." I quote this statement of Will Mayo's, because it brings out so strongly the shift in emphasis from the ultraconservative treatment by apparatus to the quicker, more efficient and accurate surgical correction.

Meanwhile, great events were occurring in the United States. In one winter (1911), two surgeons, Fred Albee and Russell Hibbs, published their methods of fusing the spine for the more effective treatment of Pott's disease. Previous surgical attack on tuberculosis had consisted of attempts at radical excision, sometimes with the aid of pure carbolic acid as a sterilizing agent. The spine, because of the inaccessibility of the vertebral bodies, had remained immune to these attacks, but many hips had suffered badly under this treatment. The knees had done better, because fusion had frequently resulted after the excision. Albee and Hibbs worked out their methods quite independently; each, however, had the same idea of producing a physiological internal bony splint to replace the plaster corsets and braces which were then in current use. Hibbs, as you all know, used numerous small bone chips; Albee, decrying these grafts as "chicken feed", implanted a tibial graft, removed with his motor saw, long enough to span two sound vertebrae above and below the involved area. I first met Albee in the Spring of 1913 at the congress of the *Deutsche orthopädische Gesellschaft* in Berlin. Ellis Jones was with him as his assistant. Albee was a poor linguist (he did not speak German, French, or Spanish), and I gained his favor by translating for him. As a result, he invited me to join his Staff at the Postgraduate Hospital when I returned to New York in 1917. Before that time, however,

Biesalski and I managed to get the Albee motor saw and with it we performed about twenty spine fusions at the *Oskar-Helene Heim*. The results in these cases were not encouraging; although the grafts healed satisfactorily, the disease persisted in its course and, eventually, the graft either fractured at the apex of the curve or, as proved by autopsy, itself became involved in the tuberculous process.

When I returned to New York in 1917, I found the keenest rivalry between the Postgraduate Hospital, where Albee was the chief, and the New York Orthopaedic Dispensary and Hospital, where Russell Hibbs held full sway. Both were self-made men and both had to fight up-hill battles. Hibbs had a little easier time, for the directors of the New York Orthopaedic Hospital soon recognized his outstanding ability and made him Chief Surgeon, replacing Dr. Newton Shaffer. Because of this, Hibbs incurred Shaffer's enmity, and was denied entry into our Association for many years. This must have been hard for him, since he had a sensitive proud nature. Eventually, when a committee of our Association investigating scoliosis studied his records at the New York Orthopaedic Hospital, they found them to be so far superior to any others that the usual three-year waiting period for admission was dispensed with, and Hibbs was at once admitted to membership.

Albee came to New York as a poor young man without a friend and without a hospital connection. At first, he could get nothing except a job in the X-Ray Department of the Postgraduate Hospital. He eked out a bare existence, living in a tiny apartment in Washington Heights. Even after he had begun his orthopaedic clinic, he had few private patients until suddenly, almost overnight, after his article on the treatment of Pott's disease had been published, he became one of the most sought-after surgeons of the country. He extended his bone-grafting methods to every part of the body. His ingenuity was amazing; his dexterity in the use of his electric saw has never been equaled. This motor saw, a clever modification of the tool used by Hartley and Kenyon, changed the entire character of bone surgery. Bone-grafting operations became a kind of physiological carpentry with Albee the master craftsman. He favored the tibial graft rather than the iliac, because the tibial graft could be so well adapted to accurate shaping, but he understood the physiological significance of the spongiosa and always transplanted it with the cortical bone. He had great success with the sliding bone-graft operation for non-union. Thanks to his so-called bone mill, a device for rounding the grafts, he could make dowels of various sizes which were invaluable in helping to fix the grafts. He hated "hardware", a term he applied indiscriminately to all nails, plates, and screws. Nothing pleased him more than to demonstrate to his students the failure of such "unphysiological methods" and the superiority of the autogenous bone grafts, particularly when shaped by the Albee motor saw. He was the one, it may be recalled, who operated on Dr. Sterling Bunnell's fractured femoral neck, after a year of non-union. He freshened the bone ends, inserted numerous small, spongy bone grafts between the ends, then drove a strong tibial graft, rounded by the dowel-shaper, from the trochanter through the neck. Union was solid in three months. Incidentally, during those many weeks at the Postgraduate Hospital, Dr. Bunnell amused himself by writing an article on the flight of birds. Albee and Hibbs were for many years bitter professional rivals, but, in the perspective of time, it is now realized that they actually constituted a team who perhaps did more to advance bone surgery than any other two men. It is also pleasant to note that their rivalry ended in a happy event,—the admission of Dr. Albee's son to the New York Orthopaedic Dispensary and Hospital as a resident.

The contributions of Royal Whitman, thanks to his excellent publications, are so well known that they need not be rehearsed here. It is significant that, although his actual technique is now seldom employed (very few surgeons use the plaster abduction spica for fractured femoral necks, or astragalectomy for paralyzed feet, or the loop operation to correct valgus), the mechanical principles underlying these procedures are as effective today as when first promulgated by Whitman. Those of us who were fortunate enough to

be his pupils can never forget his great gifts as a teacher; he literally compelled his pupils to use every sense in learning to examine properly. He could be caustic to the point of cruelty, but he gained his end: imparting the power of accurate examination to his students.

Of the Boston group, Goldthwait, who at one time had been particularly interested in surgery and had been the first to devise an efficient method to correct recurrent dislocation of the patella, swung away from operative orthopaedics because of an overpowering interest in posture and derangements of the lumbosacral region. Lovett, Bradford's successor as John Ball and Buckminster Brown Professor of Orthopaedic Surgery at Harvard, added greatly to our knowledge of scoliosis by his research on the cadaver. He founded the Harvard Infantile Paralysis Commission and became a consultant to the New York Board of Health after the terrible epidemic of 1916. His numerical classification of partially paralyzed muscles is still in use today. Although not a surgeon himself, he foresaw the future of our specialty and encouraged the surgical efforts of his promising young assistant, Frank Ober. Elliott Brackett was not only a fine surgeon but, as the Editor of our *Journal*, developed it into the outstanding specialist publication of the world. He combined indefatigable working power with a sweetness, humility, and breadth of vision such as I have never seen in any other human being.

In Baltimore, William Baer was joined by George Bennett, a recent graduate of the Hospital for Ruptured and Crippled. Baer was one of those warm-hearted, genial, great men, full of the "milk of human kindness", who combined great surgical power with his love of children and dogs; adults were, however, not excluded from his affection. He did pioneer work in developing arthroplasties and was the first to treat osteomyelitis by maggots.

Michael Hoke in Atlanta, one of those modest men who never allowed his modesty to shake his faith in the accuracy of his own knowledge, taught orthopaedic surgeons more about the human foot than anyone before or since. His operative correction of club-foot and of paralytic foot deformities is still in use today and will, I think, continue to be used. It was through his efforts that the Shriners organized their system of hospitals for crippled children.

In Philadelphia, Gwilym G. Davis and the elder Willard transmitted their orthopaedic skill to a group of able pupils, all now Senior Members of our Association. In Chicago, John Ridlon and John Porter; in Cincinnati, Albert Freiberg; in Memphis, Willis Campbell; in San Francisco, Harry Sherman; in St. Paul, Arthur Gillette—all united to give a mighty impetus to the rising new specialty. In Canada, too, orthopaedic surgeons following the example, first, of Dr. Clarence Starr, and then of his successor, Dr. William E. Gallie, did not lag behind their brothers in the States.

As I think back over this period from 1910 to 1920 I am staggered by the changes which occurred. My review has perforce been cursory, and I have had to omit mention of many men who have greatly aided our orthopaedic advance, but if, in my portrayal of some of the important personalities instrumental in this evolution, I have given some conception of how these changes evolved, of the human-interest story underlying the historical development, I shall have achieved my purpose. It is good for us today to realize our indebtedness to the past.

REFERENCES

1. Mayer, Leo: Orthopaedic Surgery in the United States of America. J. Bone and Joint Surg., **32-B**: 461–497, Nov. 1950.
2. Mixter, W. J., and Barr, J. S.: Rupture of the Intervertebral Disc with Involvement of the Spinal Canal. New England J. Med., **211**: 210–215, 1934.
3. Watson, Frederick: The Life of Sir Robert Jones. London, Hodder and Stoughton Limited, 1934.

DISCUSSION

Dr. James W. Sever, Boston, Massachusetts: Dr. Mayer's paper has been extraordinarily interesting to me. I've known all these men whom Dr. Mayer has talked about. When I read my first paper at The American Orthopaedic Association in Washington in 1907, the Association was small; we had perhaps thirty or thirty-five members. Dr. Bradford, under whom I trained, and Dr. Lovett, in whose office I worked for so many years, I knew well. Lovett was a hard task-master; he was a hold-over from the brace days and he was very much interested in and very insistent upon teaching the art of brace-making to his house officers and having his patients equipped with *perfectly* fitting braces. He knew nothing about surgery. I think that in the thirteen years we did perhaps one tenotomy, as a private case, and one amputation of an arm for a sarcoma of the elbow.

When I started doing orthopaedic surgery, The American Orthopaedic Association was in its transition stage between the brace surgeons and the surgically trained orthopaedic men; and when I was asked about that time to take over the orthopaedic surgery at the Boston City Hospital, I was told by the surgeons that the only patients whom I could treat were those with flat feet, scoliosis, and rickets. Well, I didn't want to do that, because it didn't seem to me worth while. Dr. Brackett at that time was at the Massachusetts General Hospital and all of you knew Dr. Brackett and the wonderful work he did, not only in surgery, but also as Editor of our *Journal* for many years. He developed it to the point from which Dr. Rogers has carried on.

Dr. Ralph R. Fitch, Northeast Harbor, Maine: It seems to me that we are fortunate in having Dr. Mayer present a paper which recalls to us the evolution of orthopaedic surgery. So rapid have the changes been in recent times that we are apt to forget the earlier days of the specialty.

The American Orthopaedic Association was formed in 1887. During the next several years the members were called orthopaedists and nicknamed strap-and-buckle men. Their work had to do with deformities in children. Therapeutic measures consisted largely of physical exercises, manipulations, applications of plaster-of-Paris casts, subcutaneous tenotomies, and infrequent surgical operations.

About the turn of the century, the orthopaedic field began to expand rapidly, stimulated by modern surgery and the extension of the specialty to include the treatment of patients in all age groups. When the orthopaedist became the orthopaedic surgeon, the general surgeon soon recognized his true worth, and Dr. Gibney's prophecy, made in 1891, that orthopaedic surgery would sometime include the treatment of fractures, came true. In 1907, all visiting general surgeons at the Rochester General Hospital agreed to have all fractures, excepting those of the cranium and ribs, assigned to the Orthopaedic Service. That arrangement has been followed to the present time. This is but an example of what was going on in the realm of fractures.

Dr. Mayer has given us verbal pictures of some of the men who were working in the orthopaedic field. He spoke in glowing terms of Lange of Munich, whom I met in Budapest in 1909, and I now endorse all that Dr. Mayer has said about this great surgeon and fine gentleman. Lorenz did a great work in the field of congenital dislocation of the hip. By his drastic manipulation, he started intensive work by many others on a very difficult problem. Hoffa, of Berlin, in an effort to reduce trauma of the tissues, developed an open operation for reduction of the dislocation. Bradford, of Boston, I believe, used the first apparatus for the reduction of the dislocation, and some years later Hibbs of New York developed a table that made reduction much easier. It was only after many years had passed that it was realized that forcible reduction of a congenitally dislocated hip almost invariably results in a malformed hip joint without normal functional ability. The great turning point in the treatment of congenital dislocation of the hip came when Putti, of Bologna, demonstrated that bilateral abduction of the thighs in a simple frame continued through the early weeks or months of a baby's life would permit the dislocated femur to glide into the acetabulum.

In 1913, Robert Jones gave a long-to-be-remembered dinner at the Royal Automobile Club to the members and guests of the Orthopaedic Section of the International Medical Congress which was meeting in London. After dinner Robert Jones called on one man from each of the countries represented at the Congress to speak. Putti knew but very little English. He said only a few words, which with his grace and charm produced the greatest ovation given any speaker.

In 1908, I visited Robert Jones in Liverpool, saw his remarkable work at his office, and during an afternoon at the Royal Southern Hospital saw him perform twenty-four operations. The next afternoon I went to the County Hospital at Baschurch to see his crippled children, who profited by one of the early demonstrations of fresh-air treatment. We returned to Robert Jones's house a little after ten in the evening and enjoyed to the utmost a remarkably good dinner.

Robert Jones led a full life, devoted to the welfare of mankind. I believe that he is recognized as the greatest orthopaedic surgeon of his time.

Proceedings

THE AMERICAN ACADEMY OF ORTHOPAEDIC SURGEONS

The Annual Meeting of The American Academy of Orthopaedic Surgeons was held at the Hotel Statler and Hotel Biltmore, Los Angeles, January 29, 30, and 31, and February 1, 2, and 3, 1955. Dr. T. Campbell Thompson presided. On the morning of the last day of the meeting, the new President, Dr. Walter P. Blount, was inducted into office and was escorted to the chair.

For the first time in the history of the Academy, six full days were necessary in order that the Scientific, the Audio-Visual, and the Instructional Course programs might be completed and the Scientific, the Gadget and New Idea, and the Technical Exhibits could be visited by the more than 2,500 surgeons who attended the meeting.

At the Annual Banquet, held on Wednesday, February 2, President Thompson introduced the guests of honor, Dr. and Mrs. G. C. du Toit, of Johannesburg, South Africa, and formally welcomed them to the meeting. Dr. du Toit replied in a very pleasant and witty vein, attesting to the utmost good will and friendliness which the surgeons of his country feel for their American colleagues.

For his study of diseases involving the growth centers of bone, Dr. Charles Weer Goff, of Hartford, Connecticut, received the 1954 Kappa Delta Award of one thousand dollars for the best research related to orthopaedic surgery and performed by an American citizen. The presentation was made by Dr. Donald E. King of San Francisco, Chairman of the Committee on Scientific Investigation of the Academy.

President Thompson then introduced Mrs. Harold Eads of Altadena, National Press Director of Kappa Delta Sorority, the sorority whose members have for so many years contributed to scientific research in the field of orthopaedic surgery through the annual Kappa Delta Award. In acknowledging the Academy's appreciation, expressed by President Thompson, she told in a gracious and comprehensive speech of the organization of the Kappa Delta's activities in the care of crippled children and of the interest of the Sorority in the work of the Academy.

President Thompson announced that the exhibit of Dr. W. B. Looney and Mr. M. Colodzin on The Late Effects of Internally Deposited Radio-Active Materials received the largest number of votes from surgeons attending the meeting and was thus judged the best scientific exhibit of the 1955 meeting.

The American Board for Certification of the Orthopaedic and Prosthetic Appliance Industry, Inc., then presented to Dr. Clinton L. Compere a certificate of appreciation for his work as Chairman of the Board of Examiners of that organization on the completion of his three-year term of office.

Miss Florence L. Daland, Assistant Editor, who is retiring next August from the active staff of *The Journal of Bone and Joint Surgery*, was presented by the Editor, Dr. William A. Rogers, with an engrossed tribute which read as follows:

> For almost thirty years you have served The Journal with great distinction. Eminently capable, untiring in your efforts, skillful in the arts of publishing, bringing to your task of Assistant Editor and business manager a devotion to duty that is beyond praise, you have played a prominent and vital part in establishing and maintaining The Journal's standards. It is in no small degree due to your efforts and to your idealism that The Journal occupies the place it does in the world of surgery today.
>
> There is scarcely an experienced orthopaedic surgeon in this country, and few abroad among the older men, with whom you have not collaborated in recording his achievements accurately and with befitting dignity.
>
> So valuable has been your contribution to The Journal that the Board of Trustees at their meeting in January 1954 voted to suspend, in your case, the Corporation's rule of retirement, extending your tenure of office for one year. At the same meeting it was voted to appoint you at the time of your retirement a consulting editor and to duly supplement your Social Security payments.
>
> On behalf of The Board of Associate Editors, and of American orthopaedic surgeons everywhere, I wish to express our deep regret as your active service comes to an end. As you lay down the cares and burdens of office and enter upon a period of lessened activities, we lose one who has been a tower of strength. In token of our appreciation of all you have done for surgery, for The Journal, and for us as orthopaedic surgeons, but above all as an expression of our esteem and affection, we herewith present you a cheque for twenty-five hundred dollars. It is to be spent as you see fit but in some personal way such as travel or for some comparable interest.

On Monday, January 31, Dr. T. Campbell Thompson, the President of the Academy, addressed the entire membership. His address, directed especially to the new members, follows:

PRESIDENTIAL ADDRESS

Old members, new members, wives, and friends, on this memorable occasion, the Twenty-third Annual Meeting of The American Academy of Orthopaedic Surgeons, it is my pleasant duty to welcome 185 new members into our organization.

When the number of new members inducted each year became so great that it was impossible to greet them individually and hand them their diplomas, Dr. J. E. M. Thomson, your fourteenth President, was selected to welcome the group as a whole. His memorable address to the 1954 group, published in the April issue of the Academy Bulletin, expresses in the best possible way the welcome that the old members wish to extend to the new ones. I would like to suggest that a reprint of this be furnished to each new member.

It gives me great pleasure to combine my few remarks as outgoing President with a word of greeting to our new members. The older members have heard so many Presidential Addresses that there is nothing that I can say to them which has not been said before and in better form.

You who are now entering our ranks are well qualified orthopaedic surgeons with years of training behind you and you are now well established in your chosen field. The older members of the Academy welcome you wholeheartedly and want to encourage you to engage freely in all Academy activities.

This Academy was started twenty-three years ago by a small group. These far-sighted men realized that the specialty was rapidly growing and that there was need for an organization which would include all well trained orthopaedic surgeons and would be dedicated to the advancement of orthopaedic surgery as a specialty. The best way that this could be done was to attract doctors of the highest caliber to this field and to provide adequate training facilities for them.

Shortly after this Academy was started, The American Board of Orthopaedic Surgery, composed of three representatives from The American Orthopaedic Association, three from the Orthopaedic Section of the American Medical Association, and three from our Academy, was founded. As a matter of fact, these Board members, although elected from different groups, have always been members of this Academy. This Board has done a marvelous job in raising the standards of orthopaedics in the United States. Although some of you may have felt that their rulings have been unnecessarily strict in certain instances, I can assure you that their primary object is to ensure that only surgeons with adequate ability, training, and ethics will be allowed to take the Board examinations and become eligible for membership in this organization. Unfortunately, a number of young aspirants consider that the eligibility requirements of the Board constitute the outline of a complete orthopaedic training. On the contrary, these requirements were formulated by the Board only as a minimum. No orthopaedist worth his salt should be satisfied with this minimum.

I think you will agree that the ideal of every orthopaedic surgeon should be to care for each patient with a crippling disease or an injury to the locomotor system in such a way that he can say to himself: "This result is as good as could be obtained". With changing times, orthopaedic methods have changed and will continue to change. One hundred years ago the orthopaedists were rightfully called strap-and-buckle doctors. In the past fifty years surgical procedures for relief of orthopaedic conditions have developed at a rapid rate. The results have sometimes been spectacular, too often mediocre, and at times catastrophic. The decision to use any method, operative or otherwise, should be based upon a reasonable assurance that the patient would be improved and not upon the fallacious approach: "He was getting no better; so I had to operate". Good judgment in orthopaedic surgery determines the ultimate result of treatment much more than does the dexterity of the individual operator. It should be one of the main purposes of this Academy to help its members to use the best possible judgment in their choice of treatment, and it is

FIG. 1
Dr. William S. Baer

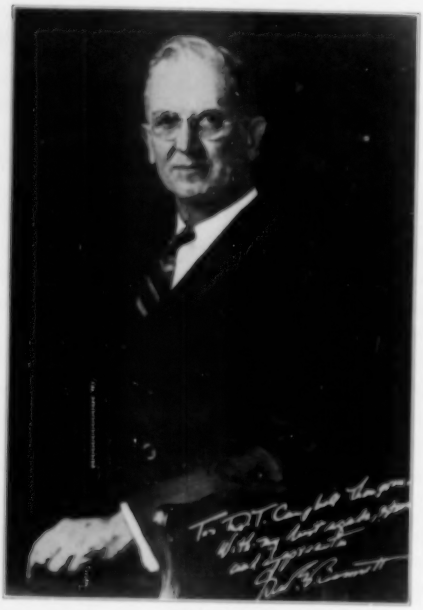


FIG. 2
Dr. George E. Bennett

the duty of every member not only to keep himself well informed and up to date, but to assist others in developing the medical judgment which comes to some quickly, to some slowly, and unfortunately to some scarcely at all.

The decrease in the incidence of bone tuberculosis and osteomyelitis and the startling new developments in therapy are changing the character of orthopaedic practice. The increase in the speed of transportation has caused a parallel increase in the number of severe injuries. There is so much of this traumatic work that even a small town of 5,000 or 10,000 people should have someone qualified to care for these injuries. Fortunately, the number of young orthopaedic surgeons who have been trained and have passed their Board examinations has reached a point where the greater part of this fracture work can be cared for by orthopaedists. The public is also becoming aware of the fact that there is a definite advantage in having a "bone man" for a bone injury. This means that a very large part of our work in the future will be in the treatment of trauma. Much of our training, therefore, should be directed along such lines.

FIG. 3
Dr. Robert W. Johnson, Jr.

Training orthopaedists can be one of the happiest, most stimulating, and rewarding experiences in a surgeon's life. It is usually true that training of younger men is done best by those who are willing and anxious to learn themselves. There is a definite limit to the amount of actual surgical work which any one man can do in a lifetime, no matter how hard or how

many years he works. However, there is no limit to the good that he can do by transmitting as much as possible of his skill and knowledge to his junior colleagues. In orthopaedics it takes many years to accumulate real experience. A large part of this can be passed on to the coming generation, so that each one of them will not have to "start from scratch". There is no reason that your good should be "interred with your bones". You new members have not completed your training, nor should any member of this Academy, even in the group of Emeritus Members, consider that his training period is completely finished. You must carry on this mutual training program in order to keep everybody in the Academy up to date and to stimulate each group of new members to continue in their training, even though they have been qualified by The American Board of Orthopaedic Surgery and admitted to this Academy.

FIG. 4
G. R. Girdlestone, F.R.C.S. (at right)

There is not time here to go into the details of how many months of each subject should be required of each orthopaedic resident, or what percentage of children's, adult, and fracture work each should have. Certainly the basic requirements, as set forth by The American Board of Orthopaedic Surgery, should be considered a minimum and they were meant to be only that. Perhaps the requirements of the Orthopaedic Board should be like those of a college where a degree is given after four years of work, one half of which is devoted to fundamental subjects and the rest to electives.

The primary requisites for training an orthopaedic surgeon are:

1. That he be a good medical doctor, possessing certain special interests and abilities; patience is one of the most important.
2. That he have had training in the fundamental principles of good atraumatic surgery. (Surgical technique cannot be learned while doing difficult orthopaedic operations.)
3. That he have sufficient energy and interest to familiarize himself with past methods, as well as recent advances in the treatment of numerous only slightly related conditions.
4. That the opportunity be provided for such a man to see and examine and later to treat a large number of patients with all types of orthopaedic disabilities.
5. That he have the stimulation and guidance provided by close and friendly association with capable colleagues.

No amount of special courses in basic science or practical work can take the place of this true preceptorship type of training.

The development of sound surgical and medical judgment should be the most important aim of any training program. Without it, all the book learning and surgical skill of a brilliant young orthopaedic surgeon will not only be wasted but may lead him into serious difficulties.

FIG. 5

Sir Robert Jones

This judgment cannot be acquired by mere imitation, although it is a natural reaction and often the right one to make a decision based upon what you believe your preceptor would do under the same circumstances.

Residents fresh from surgical training are inclined to think that clinic work is drudgery to be avoided and many approach each patient only as a potential surgical exercise. Nothing can be more harmful to the resident in training or more degrading to orthopaedic surgery than to have such a man approach a new patient with a sharply honed scalpel only poorly concealed. In most types of orthopaedic practice, one should expect to see (and treat) at least fifty patients who do not need surgical treatment for each one who does.

Methods of training will naturally vary; this is right and is dependent upon conditions. When a large number of patients must be seen by a few doctors, many teaching opportunities must necessarily be lost. Where there are only a few patients, each one can be used very well for teaching and conference instruction, even though the clinical problem does

not seem important. The proper patient-doctor relationship should, however, be carefully maintained. No theoretical discussion or disagreement upon treatment should take place in front of the patient. The doctor, be he resident, attending surgeon, or family doctor, who has the direct personal contact with the patient should be familiar with the patient's personal as well as physical problems.

If the young orthopaedic surgeon is to develop sound judgment, he should examine every patient thoroughly, use his own knowlege and experience, supplemented if necessary from the library, and come to an independent decision as to the proper treatment. It is well for him to write this down, as it is very easy for him to say to himself: "I too would have done that". To help develop judgment, the senior man at any rounds or conference should request these opinions from the junior members before he has expressed his own. Oftentimes the senior man can obtain valuable information and advice from his younger colleagues if he refrains from squelching their opinions by making too early and too positive statements of his own.

FIG. 6

Dr. Philip D. Wilson (center foreground)

I have been fortunate in having had the opportunity to work closely with five outstanding orthopaedic surgeons and have had most profitable close association with many others. I envy the young men now in training their opportunities to take special courses, to review their anatomy in the dissecting room, and to do research in well equipped laboratories; but the importance of close daily contact with men whose judgment they respect cannot be emphasized too much.

It is quite natural for a young doctor with surgical training and interests to take up a specialty. This change or concentration of interest is often caused by the influence of some person. I was attracted to orthopaedics by Dr. William S. Baer (Fig. 1) whom you probably all know as the originator of the maggot treatment for osteomyelitis. All of his colleagues were stimulated by his original ideas. He was most thorough in his physical examinations and for this reason he was unusually accurate in his diagnoses.

Dr. George E. Bennett (Fig. 2) is a model for promptness (the exact opposite of Dr. Baer). To approach his surgical skill, especially in the treatment of athletics injuries, has long been my aim.

Dr. Robert W. Johnson, Jr. (Fig. 3) taught me the importance of the proper patient-doctor relationship.

I spent two happy and profitable years with Mr. G. R. Girdlestone of Oxford (Fig. 4). (Perhaps you will recognize the famous profile of the man with him.) His knowledge of tuberculosis was profound, his surgery was the best, and his complete adherence to the principles of Hugh Owen Thomas and Robert Jones was most instructive.

I did not know Sir Robert Jones personally, but his dog Barry was my very close friend (Fig. 5).

For the past twenty years I have been fortunate in continuing my training with another of the early Presidents of this Academy, Dr. Philip D. Wilson (Fig. 6). With his varied experience, his vision, and his intense interest both in research and in the training of orthopaedic surgeons, he has been a constant stimulus to all around him.

It is customary for the Presidents of this Academy to reminisce, but I would prefer to emphasize that you newly elected younger men will soon be looked up to for guidance and inspiration by the young men who follow after you, just as I look up to those men to whom I have expressed my gratitude today and whose examples have meant so much to me. It, therefore, behooves you to apply yourselves with all your will and all your talents that you may be worthy of the trust that will be placed in you. The Academy is yours; the Academy expects you to do your part.

I have tried to give you an idea of what the Academy means to its members. I also would like to remind you that, as each man becomes a member, he becomes also a personal representative of the Academy. His efforts toward increasing his own knowledge and imparting this knowledge to others should not end here at this Annual Meeting, but should continue throughout this year and the years to come. The best way to learn is by teaching, and teaching does not have to be restricted to a formal medical school, a postgraduate training program, or a special meeting like this. Every one of you has the opportunity to give of the knowledge, the skill, and the training that are yours only for this lifetime. Even more important is the fact that each one of you is not only an orthopaedic surgeon and a member of the Academy but also a doctor, primarily dedicated to "give his best" to improve the lot of the crippled and injured.

In the words of Lincoln, "The world will little note nor long remember what we say here", but it cannot help noting and appreciating what you who are here today will *do* in the future.

At the close of the President's Address, the following new members were inducted:

John Frank Abele, M.D., Portland, Oregon
Hollis LeRoy Ahrlin, M.D., Rapid City, South Dakota
Karl S. Alfred, M.D., Cleveland, Ohio
Sherman William Allred, M.D., Salt Lake City, Utah
Kirk J. Anderson, M.D., Seattle, Washington
Thomas Sherwood Barron, M.D., Fort Sill, Oklahoma
Pascal Gayle Batson, Jr., M.D., Pensacola, Florida
George Paul Beach, M.D., Daytona Beach, Florida
George C. Beattie, M.D., Berkeley, California
Robert C. Bechtol, M.D., Santa Rosa, California
Norman Russell Beck, M.D., Salt Lake City, Utah
Bradford S. Bennett, M.D., Winchester, Virginia
Norman C. Berube, M.D., Manchester, New Hampshire
George Herman Bischoff, M.D., Akron, Ohio
Donald W. Blair, M.D., Des Moines, Iowa
Vilray P. Blair, Jr., M.D., St. Louis, Missouri
John Avery Blosser, M.D., Oakland, California
Gustavus Denton Bock, M.D., Long Beach, California
Edwin Gladstone Bovill, Jr., M.D., San Francisco, California
Earl W. Brannon, M.D., Willoughby, Ohio
John James Brennan, M.D., San Francisco, California
Francis M. Brink, M.D., Spokane, Washington
Jacob Bronitsky, M.D., Martinsburg, West Virginia

Charles W. Brown, M.D., Denver, Colorado
Kenneth A. Brown, M.D., Newtonville, Massachusetts
Walter Henry Brown, Jr., M.D., Akron, Ohio
August Roy Buerkle, M.D., Flushing, New York
Joseph G. Burd, M.D., Nashville, Tennessee
Dwight Willard Burney, Jr., M.D., Omaha, Nebraska
Bradley W. Carr, M.D., Chicago, Illinois
Stephen M. Chasten, M.D., Grand Forks, North Dakota
Sigmund Chessid, M.D., New York, N. Y.
John Douglas Christian, M.D., Little Rock, Arkansas
Arthur Anthony Civello, M.D., San Francisco, California
Paul Maxon Clark, M.D., Albany, New York
Stanley A. Clark, Jr., M.D., Stockton, California
Howard McGinnis Clemmons, M.D., Butte, Montana
Elliott Abel Cobb, M.D., Cedar Rapids, Iowa
Warren A. Colton, Jr., M.D., Phoenix, Arizona
Paul M. Consigny, M.D., Peoria, Illinois
Robert Henry Cram, M.D., Philadelphia, Pennsylvania
Andrew Hoyt Crenshaw, M.D., Memphis, Tennessee
Francis J. Crimmings, M.D., Rochester, New York
John G. Davidson, M.D., Fort Harrison, Montana
Jose G. Davila-Lopez, M.D., Ponce, Puerto Rico
E. Vernon Davis, M.D., Camden, New Jersey
William Townsend Davison, M.D., Port Huron, Michigan
William J. D'Elia, M.D., Asbury Park, New Jersey
Robert E. DeLong, M.D., Kalamazoo, Michigan
Vernon R. Dennis, Jr., M.D., Berkeley, California
Robert O. Denton, M.D., Birmingham, Alabama
Peter Van Cleef Dingman, M.D., Waterbury, Connecticut
William Fielding Donaldson, M.D., Pittsburgh, Pennsylvania
Ralph Elwood Donnell, M.D., Plainview, Texas
Malcolm B. Downs, M.D., Glendale, California
James T. Dresser, M.D., Van Nuys, California
Robert Marshall Drisko, M.D., Kansas City, Missouri
John C. Dunn, M.D., Hicksville, New York
Thomas M. Durham, Jr., M.D., Hot Springs, Arkansas
Richard F. Farrell, M.D., Stamford, Connecticut
Albert B. Ferguson, Jr., M.D., Pittsburgh, Pennsylvania
M. Richard Ferguson, M.D., Santa Monica, California
Richard Spence Fletcher, M.D., Buffalo, New York
Maxwell P. Fonda, M.D., Pomona, California
Arthur Edward Fouke, M.D., Dayton, Ohio
William Lewis Franklin, M.D., Indianapolis, Indiana
Elihu Friedmann, M.D., Scranton, Pennsylvania
Carl Monroe Friesen, M.D., Lexington, Kentucky
Dellivan M. Fuiks, M.D., Sacramento, California
Robert E. Funsch, M.D., University City, Missouri
J. Bruce Galloway, M.D., Asheville, North Carolina
Francis Henry Gay, M.D., Columbia, South Carolina
Sangwill L. Gernstetter, M.D., Poplar Bluff, Missouri
Alba R. Glassburn, Jr., M.D., Denver, Colorado
M. Paul Goodfried, M.D., Dallas, Texas
Charles Shelly Graybill, M.D., Lawton, Oklahoma
Albert Haddad, M.D., Worcester, Massachusetts
Cameron Baldwin Hall, M.D., Beverly Hills, California
Edward Crampton Harris, Jr., M.D., Mobile, Alabama
J. Henry Heinen, Jr., M.D., Chicago, Illinois
Edward Drewry Henderson, M.D., Rochester, Minnesota
James Rudolph Herz, M.D., Reno, Nevada
Wallace Earl Hess, M.D., Salt Lake City, Utah
Burton Paul Hoffman, M.D., White Plains, New York
Clifford William Hogan, M.D., Jamestown, North Dakota

Alfred W. Humphries, M.D., South Euclid, Ohio
E. Palmore Irving, M.D., Petersburg, Virginia
Albin A. Jahns, M.D., Gary, Indiana
Einer W. Johnson, Jr., M.D., Rochester, Minnesota
Paul L. Johnson, M.D., Bismarck, North Dakota
Gerald Bernard Joyce, M.D., Topeka, Kansas
Richard Edward Kendrick, M.D., Sacramento, California
Howard Curtis Kingsbery, M.D., Lima, Ohio
Harvey Kopell, M.D., New York, N. Y.
Leonard Kremer, M.D., Paterson, New Jersey
J. Harold LaBriola, M.D., Los Angeles, California
Donald Francis Larkin, M.D., Providence, Rhode Island
William B. Lewis, Jr., M.D., Scott Air Force Base, Illinois
Ralph Theodore Lidge, M.D., Chicago, Illinois
Ernest C. Lineberger, M.D., Fort Campbell, Kentucky
Russell I. London, M.D., Philadelphia, Pennsylvania
J. Otto Lottes, M.D., St. Louis, Missouri
Alfred Edgar Luckett, M.D., El Paso, Texas
Ralph Dean Luther, M.D., Spokane, Washington
Edward P. McCreery, M.D., Bridgeport, Connecticut
W. J. McDonald, M.D., Crookston, Minnesota
Glenn Leslie McElroy, M.D., Columbia, Missouri
Justin Churchill McNutt, M.D., Bloomington, Illinois
Howard William Mahaffey, M.D., Madison, Wisconsin
John Benson Manly, M.D., New York, N. Y.
Victor S. Mateskon, M.D., Petoskey, Michigan
Donald J. Maylahn, M.D., Chicago, Illinois
Charles Newell Mell, M.D., Oakland, California
John W. Metcalf, M.D., Carlsbad, California
Leslie C. Meyer, M.D., Greenville, South Carolina
Edward A. Millar, M.D., Wilmette, Illinois
Paul Ralph Miller, M.D., Columbus, Ohio
William R. Miller, M.D., Wichita, Kansas
Douglas K. Millett, M.D., Minneapolis, Minnesota
John Chrysostome Minihan, M.D., North Quincy, Massachusetts
Floyd William Mohler, M.D., Columbus, Indiana
Charles I. Nadel, M.D., Irvington, New Jersey
Charles Sumner Neer, II, M.D., New York, N. Y.
Paul Irving O'Brien, M.D., Brookline, Massachusetts
Stephen L. Odgers, M.D., Missoula, Montana
Daniel Elliott O'Reilly, M.D., St. Louis, Missour
Edwin J. Otis, M.D., Long Branch, New Jersey
William T. Payne, III, M.D., Dallas, Texas
Herbert Eugene Pedersen, M.D., Pleasant Ridge, Michigan
O'Neill L. Pollingue, M.D., New Orleans, Louisiana
Richard W. Pomeroy, M.D., Lansing, Michigan
T. Gordon Reynolds, M.D., Glendale, California
Robert N. Richards, M.D., Chambersburg, Pennsylvania
Daniel Clifford Riordan, M.D., New Orleans, Louisiana
William J. Rogers, III, M.D., Tonawanda, New York
Howard William Schneider, M.D., Homewood, Illinois
Nathan Alter Schwalbe, M.D., Clifton Springs, New York
Alfred Peter Seminario, M.D., St. Petersburg, Florida
Leonard A. Shepanek, M.D., Chicago, Illinois
Julius Yale Sher, M.D., Beverly Hills, California
Howell Hood Sherrod, M.D., Johnson City, Tennessee
Richard L. Shorkey, M.D., Beaumont, Texas
Bret W. Smart, M.D., Oakland, California
Joseph I. Soffer, M.D., Chicago, Illinois
C. Arthur Spaulding, Jr., M.D., Monterey, California
Robert L. Sperry, M.D., North Bergen, New Jersey
Louis Spigelman, M.D., Los Angeles, California

Dumont S. Staatz, M.D., Tacoma, Washington
John Howard Sterne, M.D., Evansville, Indiana
William Sinclair Stewart, IV, M.D., Charlotte, North Carolina
Alfred B. Swanson, M.D., Grand Rapids, Michigan
Charles Mathews Swindler, M.D., Ogden, Utah
Forrest M. Swisher, M.D., Alexandria, Virginia
Ellsworth H. Tannehill, M.D., Chicago, Illinois
James Herbert Taylor, M.D., Clinton, Iowa
Jack E. Thomas, M.D., Elmira, New York
John Q. U. Thompson, M.D., Jacksonville, Florida
Ralph Thompson, M.D., Medford, Oregon
Robert G. Thompson, M.D., Chicago, Illinois
Wendell H. Tiller, M.D., Spartanburg, South Carolina
S. Fulton Tompkins, M.D., Oklahoma City, Oklahoma
Charles O. Townley, M.D., Port Huron, Michigan
Jackson E. Upshaw, M.D., Corpus Christi, Texas
Walter E. VanDemark, M.D., Sioux Falls, South Dakota
John J. VanDriest, M.D., Sheboygan, Wisconsin
Arnulf R. VanDyk, M.D., New London, Connecticut
Paul F. Wallace, M.D., St. Petersburg, Florida
Ruth Moyer Waring, M.D., Savannah, Georgia
Robert W. Weber, M.D., Tucson, Arizona
John B. White, Jr., M.D., Indianapolis, Indiana
Wendell L. Whittemore, M.D., Memphis, Tennessee
Benjamin Wiesenfeld, M.D., Perth Amboy, New Jersey
Leland G. Wilcox, M.D., Tyler, Texas
Hugh L. Williams, M.D., Indianapolis, Indiana
George G. Willis, M.D., Framingham, Massachusetts
James Nelson Wilson, M.D., Los Angeles, California
John C. Wilson, Jr., M.D., Pasadena, California
Philip D. Wilson, Jr., M.D., New York, N. Y.
Walter Barron Withers, M.D., Santa Barbara, California
Richard C. Wixson, M.D., Madison, Wisconsin
Robert L. Woodward, Jr., M.D., Louisville, Kentucky
William Haller Woodson, M.D., Twin Falls, Idaho
Thomas D. Yocum, M.D., Lexington, Kentucky
Milo A. Youel, M.D., San Diego, California
Cabell Young, Jr., M.D., Winston-Salem, North Carolina

HONORARY

G. T. du Toit, F.R.C.S., Johannesburg, South Africa

At the second Executive Session, February 3, the following officers and committeemen were elected:

President-Elect: William T. Green, M.D., Boston, Massachusetts
Vice-President: George W. N. Eggers, M.D., Galveston, Texas
Treasurer: Jesse T. Nicholson, M.D., Philadelphia, Pennsylvania
Secretary: John R. Noreross, M.D., Chicago, Illinois
Librarian-Historian: Albert C. Schmidt, M.D., Milwaukee, Wisconsin
Junior Members of Executive Committee:
S. Benjamin Fowler, M.D., Nashville, Tennessee
Jack K. Wickstrom, M.D., New Orleans, Louisiana
Member of Committee on Scientific Investigation: Frank E. Stinchfield, M.D., New York, N. Y.
Member of Committee on Public Relations: J. Neill Garber, M.D., Indianapolis, Indiana
Member of Program Committee on Instructional Courses: Otto E. Aufranc, M.D., Boston, Massachusetts
Member of Program Committee on Audio-Visual Education: Joseph E. Milgram, M.D., New York, N. Y.
Nominating Committee:
Robert L. Patterson, M.D., *Chairman*, New York, N. Y.
C. R. Rountree, M.D., Oklahoma City, Oklahoma
Harry C. Blair, M.D., Portland, Oregon
Frederick C. Reynolds, M.D., St. Louis, Missouri
David S. Grice, M.D., Boston, Massachusetts

Summaries of the papers presented during the Scientific Sessions, together with résumés of the Scientific Exhibits and the Audio-Visual Program, will appear under Proceedings in the June issue of *The Journal*.

The next Annual Meeting of The American Academy of Orthopaedic Surgeons will be held at the Palmer House, Chicago, Illinois, January 28 to February 2, 1956.

WESTERN ORTHOPEDIC ASSOCIATION

Prepared by the Editorial Committee of the Western Orthopedic Association: Merrill C. Mensor, M.D., *Chairman;* J. Vernon Luck, M.D.; K. O. Haldeman, M.D.; George L. Dixon, M.D.; and Kirk J. Anderson, M.D.

The Eighteenth Annual Meeting of the Western Orthopedic Association was held in San Francisco, California, October 13 to 16, 1954. The meeting was well attended, there being approximately six hundred members and guests present from the eleven Western States. The program covered a large field of scientific interest and was planned in such a manner that sufficient time was allowed for social activities; these were enjoyed by the members and guests and their wives. Under the able management of the President, Dr. Leonard Barnard, the meeting was one of the best and San Francisco hospitality pleased one and all.

The social activities consisted of an afternoon tour of the city in special busses; a fashion show; shopping tours directed by leading stylists in the area, and a *Koffee Klatsch* for the ladies. In the first day during the cocktail hour, the orthodox fare was varied by California wine tasting; on the next day, there was a cocktail cruise on San Francisco Bay on the motor ship Harbor Queen; and, on the last day, the President's party preceding the formal dinner dance brought the social events to an end. For the football enthusiasts, tickets for the Washington State-California game on Saturday afternoon, transportation, and a luncheon *en route* were made available.

Dr. J. Warren White of Honolulu was installed as President for the ensuing year; the next Annual Meeting will be held in Honolulu in November 1955. Other officers elected for 1955 are as follows:

President-Elect: James Lytton-Smith, M.D., Phoenix, Arizona;
Vice-President: Steele F. Stewart, M.D., Honolulu, Hawaii;
Secretary: Ivar J. Larsen, M.D., Honolulu, Hawaii;
Treasurer: V. Allen Richardson, M.D., Honolulu, Hawaii;
Librarian and Historian: Harry R. Walker, M.D., Oakland, California;
Editorial Committee (New Member): Robert D. Ray, M.D., Seattle, Washington.

Several policies of general interest were adopted by the Association; one of these may be summarized as follows: It was felt that, due to the increasingly large attendance at the Annual Meeting, it would be advisable to restrict the number of guests. Accordingly, in the future, each member will be allowed to invite one guest, the name of the guest to be submitted to the Secretary one month before the Meeting.

An important phase of the organization has been the Resident-Training-Program Awards which were originated by Past-President Vernon Thompson and which were named in his honor. A permanent Awards Committee was established consisting of the Chairman of the Scientific Program, the Chairman of the Editorial Committee, and the immediate Past-President of the Association. The 1954 Award was given to William A. Craig, M.D., and, as three theses were tied for second place, awards were made to Elmer H. Thomasson, M.D., Bernard J. Drury, M.D., and Mason Hohl, M.D. It was decided that at future meetings the invited residents and their wives would be guests of the Association with no financial obligation.

It was decided that the 1956 Meeting will be held in October at Phoenix, Arizona, under the Presidency of Dr. Lytton-Smith and that the 1957 Meeting will be held in Los Angeles.

Wednesday, October 13, 1954

Wednesday afternoon was devoted to the Audio-Visual Program; the following motion pictures were presented:

A Method of Ultrasonic Radiation. Dr. John H. Aldes [1] presented a film in which the physics of ultrasonic radiation was described, together with the indications and the technique of its application. The dangers of the method were pointed out, as were the techniques for preventing injury to tissues. Underwater applications were demonstrated for treating hands and feet. It was emphasized that such sites as the head and areas over the spinal cord and nerve trunks should not be subjected to ultrasonic radiation.

[1] 4833 Fountain Avenue, Los Angeles 29, California.

Repair of Recurrent Dislocation of the Shoulder. Dr. William R. Moloney, Jr. [2], showed a film giving in detail the performance of the Magnuson operation for the correction of recurrent dislocation of the shoulder. Minor modifications were recommended, such as the transplantation of the subscapularis laterally to the greater tubercle, without the inclusion of any of the lesser tubercle in the transplant. The film presented several patients with excellent postoperative shoulder mobility.

Subtalar Bone Blocks and Paralytic Flat Feet. Dr. Cameron B. Hall [3] presented in detail the technique of the Grice-Green subtalar bone block. Several patients were shown both before the operation and after the operation in order to demonstrate the indications for the procedure and the results which may be expected from this surgical technique. More than forty patients have been operated upon at the Los Angeles Shriners' Hospital by Dr. Wilbur Westin and Dr. Cameron B. Hall. While the principal indication has been flat-foot, resulting from poliomyelitis, the usefulness of the technique in treatment of congenital flat-foot is being explored.

Surgical Approaches to the Hip Joint. Dr. Leroy C. Abbott [4] showed in remarkable detail the anterior, lateral, and posterior approaches to the hip joint. Anatomical dissections and animated drawings were presented; these were followed by demonstrations of technique at actual operation. While no new approaches were presented, it was an outstanding review of both the anatomy of the hip region and details of the various approaches to the hip.

Going by the Mayos. Dr. John F. LeCocq [5] gave a delightful portrayal of one of Dr. Woodward's most entertaining stories of the treatment and the reactions of a young man with a fracture of the shaft of the humerus. It was partly burlesque, partly satirical, and continuously amusing—in fact, many of the sequences were hilariously funny.

Thursday, October 14, 1954

Symposium on Muscle

Electrophysiology of Muscle. Dr. Benjamin Libet [6] pointed out that the electrical events which are recordable from muscle fibers are due to variations in the resting transmembrane-potential difference. Changes in membrane permeability to various ions, induced by excitatory depolarizing agents, result in the propagated, surface-negative action potential. At the neuromuscular junction, the motor-nerve impulse releases a transmitter, apparently acetylcholine, which acts locally to depolarize the end plate of the muscle fiber. Junctional transmission is facilitated by, among other factors, stretch or repetitive activation of the motor nerve. When many muscle fibers are activated by a single motor-nerve fiber, the recorded potential (the motor-unit potential) has a greater amplitude, duration, and complexity than that recorded when a single muscle fiber is activated (fibrillation potential).

Physiology of Muscle Contraction. Dr. Henry J. Ralston [7] stated that, during the isometric contraction of isolated frog muscle, a greater tension is developed at one particular length of the muscle than at any other length. The importance of the length-to-tension relationship has not been appreciated generally, and its application to clinical problems has not been extensive, except as the principle has been applied in the treatment of the cineplastic amputee. The present success in cineplasty is based upon the appreciation of the length-tension relationship. The complete length-tension diagram consists of three curves. Two are obtained experimentally by plotting tension against length as the muscle is stretched by graded increments. The *passive tension* curve is a measure of the resistance to stretch of the elastic connective-tissue elements in the unstimulated muscle. The *total tension curve* is obtained when the muscle is stimulated and is allowed to contract isometrically. The *developed tension curve* is derived by subtracting the passive tension from the total tension for all lengths of muscle and is a measure of the tension developed by the contractile elements. Developed tension is greatest at or around the rest length of the muscle, which is defined as the point at which the passive tension becomes appreciable. The length-tension curves which have been drawn for many intact human muscles agree essentially with those obtained from experimentally isolated frog muscles and single muscle fibers.

Relation of the Electromyogram and Muscle Function. Dr. Verne T. Inman [8] said that he hoped, since the electrical potential of active human muscle is easily measured, that some relation between the total

[2] 1930 Wilshire Boulevard, Los Angeles 5, California.
[3] 153 South Lasky Drive, Beverly Hills, California.
[4] University of California Medical Center, San Francisco, California.
[5] 1011 Summit Avenue, Seattle 4, Washington.
[6] Department of Physiology, University of California School of Medicine, San Francisco, California.
[7] Department of Physiology, College of Physicians and Surgeons, San Francisco, California.
[8] Department of Orthopaedic Surgery, University of California School of Medicine, San Francisco, California.

electrical output of the muscle and its tension could be found. His investigations indicated that these two measures are parallel under certain conditions, but the parallelism was obtained only when the muscle was contracted isometrically—not when the muscle was permitted to change in length. In the intact human muscle, the total recorded electrical potential decreased with greater lengths of the muscle and increased with reduced lengths.

Clinical Significance of the Electromyogram. Dr. Bertram Feinstein [9] emphasized that the chief clinical use of the electromyogram is to determine whether the nerve supply to a muscle has been anatomically interrupted. In denervated muscle, there is spontaneous "firing" of individual fibers, giving rise to fibrillation potentials. The presence of fibrillation potentials is direct evidence of denervation. Recovery following denervation is marked by a greater complexity of the motor unit, including polyphasic waves and more complex wave forms, which is of definite prognostic value.

An Operative Method for Prevention of Calcaneocavus Foot Due to Poliomyelitis. Dr. H. E. Emmel [10] and Dr. John F. LeCocq [5] believe that there is convincing evidence indicating that early redistribution of muscle power in the postparalytic stage can prevent muscle disintegration. In children with calcaneocavus deformity of the foot, the toes and the intrinsic muscles of the foot remain intact; development of normal bone is not possible because of the loss of adequate muscle stresses on the traction epiphyses, as in the heel cord and calcaneus relationship.

Successful heel-to-toe gait has been established by transplantation into the heel cord of the tibialis anterior or the tibialis posterior and the peroneal muscles. This prevents the development of the calcaneocavus foot.

The medial hamstring muscles are in an ideal position to be used to provide a muscle motor when the power of the calf muscles has been lost. The medial hamstrings, transplanted in conjunction with triple arthrodesis and other stabilization operations in the patients in whom the tibialis posterior and peroneal muscles are also lost, can effectively transmit muscle power into the heel cord to prevent the deformity which would otherwise be certain to develop.

Slides were shown demonstrating the anatomy in cadaver extremities. A motion picture was presented showing the preoperative condition, the surgical steps in its correction, postoperative muscle-power tests, and the resulting gait. Three patients had been operated upon; these had no deformity. Six had been operated upon with the same technique after deformity had developed; in these stabilization operations were done.

Dr. Charles L. Lowman [11], in discussing this procedure, said it is feasible since the hamstring muscles are synergistic with the gastrocnemius group. He urged caution, pointing out that, in order to make the operative procedure successful, it is necessary to subject the transplant involved to continual tension (longitudinal stress) as it is only under such circumstances that the fascial inserts hypertrophy and form a true tendon. If these muscles are fastened laterally, shearing force will occur and good function will not occur. He wondered how many poliomyelitic patients have additional stretch paralysis, which is a factor in producing the calcaneocavus deformity, as a result of the type of treatment which has been instituted for the primary disease.

Postoperative care is as important as the surgery, and he brought up several questions relative to the period of immobilization, postoperative support, and readjustment exercises.

In answer to these questions, Dr. Emmel stated that the patients were left in long casts for six weeks and were put in posterior splints at night for another month. Active exercise was instituted at six weeks. No contractures developed following the surgery, but in order to obtain a good result, a strong active quadriceps is essential.

Posterior Tibial Transfer for Drop-Foot. Dr. Samuel Gaines Stubbins [12], Dr. Daniel C. Riordan [13], and Dr. Walter C. Graham [14] described a series of twenty-six transfers in patients with drop-foot resulting from irreparable damage to the peroneal nerve. The transfers were done at Valley Forge General Hospital. They stated that the usual method of tendon transfer subcutaneously around the leg is unsatisfactory because of the angle through which the transferred tendon must clear its pull. Even if it does work efficiently, it is not balanced, and frequently factors deforming to the foot result. By the method recommended, the tibialis posterior (contractile portion and tendon) are mobilized. A longitudinal slit is made in the interosseous membrane. The tendon is brought into the foot by the subcutaneous route and is fixed by a pull-out wire

[9] Department of Neurology, University of California School of Medicine, San Francisco, California.
[10] 1011 Summit Avenue, Seattle 4, Washington.
[11] 2417 South Hope Street, Los Angeles 7, California.
[12] 10515 Carnegie Avenue, Cleveland, Ohio.
[13] 1538 Louisiana Avenue, New Orleans, Louisiana.
[14] 1421 State Street, Santa Barbara, California.

suture to the third cuneiform. This allows a straight pull from the origin of the muscle to its insertion. It was emphasized that it is important to hold the foot in dorsiflexion and to avoid any slack in the transplanted tendon at the time of operation. It was likewise recommended that, in order to obtain an optimum result, resistive exercises should be instituted several weeks prior to the transplantation for the strengthening of the tibialis posterior. In this series, no deformity occurred and in most patients the tendon functioned satisfactorily. In a few, infection caused the tendon to become adherent in the interosseous membrane, but the tenodesis resulting was satisfactory. Sufficient stability resulted to eliminate the necessity for bone stabilization.

Dr. J. W. Larrabee [15], in discussing this paper, pointed out that this procedure is not a new one and that it had been tried in the past and had been discarded. This is not because of its lack of efficiency but because of failures in surgical technique in that an insufficient window made in the interosseous membrane allowed subsequent adherence to the tendon. He stressed the importance of actually exposing the interosseous membrane and cutting a window sufficient in size to allow free function of the tendon. He said that he had operated upon five patients with poliomyelitis in whom he had used a similar technique with fairly good results.

Subtalar Bone Block. Dr. G. Wilbur Westin [16] and Dr. Cameron B. Hall [2] re-emphasized that, during the years of rapid growth, in a child's foot, unstable as the result of poliomyelitis and certain other paralytic disorders, deformity continues to develop and may become painful and very much of a handicap. They pointed out that some of the children can be helped by early surgery.

They reviewed their experience with thirty-eight patients at the Shriners' Hospital in Los Angeles. They listed four types of deformity in which the subtalar bone block has been used: (1) paralytic flat-foot, (2) calcaneovalgus foot, (3) flail-foot or a partially flail-foot with no muscle imbalance, and (4) miscellaneous conditions. When indicated, muscle transplantations had been performed at the same time in order to balance the muscles of the foot. The surgical procedure used is basically that described by Grice.

In paralytic flat-foot, the primary muscle weakness is total or partial loss of power of the tibialis anterior and tibialis posterior. An almost constant finding was tight calf muscles. The resultant deformity was due to lack of support of the talus on the calcaneus; with weight-bearing, one finds the talus in equinus deformity with lateral displacement of the fore part of the foot and posterior displacement of the tarsal bones in relation to the talus.

The recovery of the normal relationship of the talus on the calcaneus by subtalar bone block restores the height and normal alignment of the foot. When the bone graft has been solidly incorporated, this relationship is permanently maintained and the normal growth of the foot is interfered with to a minimal degree if it is interfered with at all. The bone graft is placed in cancellous bone and does not involve the enchondral plate of growing bone.

In all fifteen patients, the shortened calf muscles were restored to normal length prior to surgery by gradual stretching in wedging plaster casts, the foot being held in maximum inversion. When the primary deformity had been corrected, the indicated muscle transplantations were done at the same time as the bone block.

In twelve patients with calcaneovalgus feet, equally dramatic results were obtained, especially when the stabilization was accompanied by the transplantation of good muscle power to the calcaneus. In all patients, prior to operation, there had been marked deformity.

A short-term follow-up demonstrated in many patients, clinically and by x-ray, a definite improvement in the deformity through the transplantation of muscles into the calcaneus. They found that the greatest mechanical advantage in such transplantation is obtained by placing the tendon through a drill hole in the tip of the apophysis.

Seven patients with flail-foot or partially flail-foot with no muscle imbalance were treated. The procedure should not be used when the foot is in varus deformity; when the foot on weight-bearing is in valgus deformity, the procedure is indicated.

There were four patients with miscellaneous conditions. The subtalar bone block was used in conjunction with capsulotomy to correct the malposition of a congenitally vertical talus. The bone block was also used in the treatment of painful flat-foot with no muscle impairment. Two feet were stabilized following multiple tendon transplantations.

Dr. Edwin Schottstaedt [17], in discussion, endorsed the use of the subtalar bone block, particularly in patients too young for triple arthrodeses. On the basis of his experience with this and a similar (Chambers) procedure, he was convinced that it obviated the use of triple arthrodesis at a later date. He emphasized that, if later arthrodesis is necessary, the subtalar bone block is an important preliminary step; it permits maximum growth development. He had used the procedure in patients from the ages of two and a half to eight and a half years.

[15] 85 Jefferson Street, Hartford, Connecticut.
[16] 1930 Wilshire Boulevard, Los Angeles 57, California.
[17] 384 Post Street, San Francisco 8, California.

Survival of Cancellous Chip Grafts in the Presence of Infection. Dr. Robert P. Watkins [18] reported on the use of bone grafts in grossly infected wounds. In eight of ten patients he had obtained satisfactory results. The idea was not original but, as was pointed out by one of the discussors, facts such as this which had been learned in wartime were often forgotten in times of peace. The grafts of cancellous and cortical bone were obtained from the ilium and were cut to a uniform size of approximately two millimeters. The use of these grafts was limited to patients whose skin overlying the affected defect was adequate to provide good coverage. A complete toilet of the wound with removal of all debris, sequestra, sclerotic bone, and obviously infected granulation tissue was performed. The wound was irrigated with ether and was packed tightly with the cancellous and cortical bone chips. Loose closure was done and a small rubber-dam drain was used. The limb was immobilized in a long plaster cast. Antibiotics were used postoperatively. Progress of the graft was noted by roentgenograms.

As a result of this experience, certain contra-indications were developed. It was felt that, in patients with skin too extensively scarred to permit closure, bone-grafting should not be done. In patients in whom complete removal of infected granulation tissue and debris is impossible, as in an infected intramedullary-nail tract, bone-grafting should not be done; nor should bone-grafting be done in patients in whom there is infected sclerotic bone too extensive to permit removal sufficient to obtain intimate contact between the grafting material and the bleeding bone.

Dr. Fred W. Rhinelander [19], in discussing the report, recalled the history of this procedure which had been used in wartime surgery and which was first reported in December 1944 with a series of seventy-five patients. He recounted his own experience and that of Colonel Prigge, enumerating some differences in technique which they had found successful in their patients. He believes that a preliminary sequestrectomy and open packing of the wound with petrolatum gauze for a week, followed by wet dressings daily for another week, gives more favorable granulation tissue for the implantation of the grafts. At that time, if further dead bone is evident, it is possible to remove it. He had packed the wounds open, but he readily admitted that many other men had followed Dr. Watkins' procedure of primary closure with equally satisfactory results.

Non-Suppurative Osteitis Pubis in the Female. Dr. Leon L. Wiltse [20] and Dr. Charles H. Frantz [21] reported ten new cases of osteitis pubis in the female and reviewed three found in the literature. Prints of roentgenograms in all ten cases and a photomicrograph of biopsy material from one case were presented.

Osteitis pubis is a painful condition affecting the anterior pelvic girdle. It had been thought to be limited almost entirely to the male and to follow traumatic manipulation of the tissues adjacent to the pubis, especially through cystotomy or prostatectomy.

Of the ten cases in the female, symptoms were first noticed during pregnancy in four, within two months following parturition in three, after extensive surgery adjacent to the symphysis in one, and after trauma in two. In this series, only the pubis was involved. In no patient did the disease extend to the ischia as it commonly does in the male. Spontaneous recovery was progressing in all when the patients were last seen.

Treatment was symptomatic in all patients but one; in that patient, x-ray therapy, ACTH, cortisone, and phenylbutazone were all used at various times. The disease is self-limited; hence anything which is used may give the impression of being more beneficial than it really is.

Dr. Wiltse and Dr. Frantz concluded that the condition in the female is a variant of the much more common disease in the male and that it is a localized reflex neurovascular dystrophy brought about by a combination of trauma and changes at the symphysis caused by the influence of certain hormones. These changes at the symphysis are of the nature of, but more pronounced than, those which normally take place during pregnancy. There was no evidence that infection played any part.

Specific Antimicrobial Therapy in Acute Hematogenous Osteomyelitis. Dr. Jack Wickstrom [22], Dr. Edward T. Haslam [23], Dr. Robert H. Hutchinson [24], and Dr. Roy Ledbetter [25] pointed out that the terrific impact which antimicrobial chemotherapy and antibiotics have had on infections in bone can be appreciated to some degree by the dramatic reduction of the mortality rate from 24.1 per cent. in 1936 to 0.6 per cent. in 1954 and a reduction in the hospital stay of patients with acute hematogenous osteomyelitis from 146 days in 1940 to forty-two days in 1950.

They had evaluated the closed method of treatment of acute osteomyelitis since 1944 in 165 patients, 129 of whom were followed from one to eight years. Treatment consisted in adequate systemic administration

[18] 450 Sutter Street, San Francisco 8, California.
[19] 1717 Fifth Street, San Rafael, California.
[20] 714 Professional Building, Long Beach, California.
[21] 810 Wealthy Street, S.E., Grand Rapids, Michigan.
[22] 1430 Tulane Avenue, New Orleans, Louisiana.
[23] 1430 Tulane Avenue, New Orleans, Louisiana.
[24] 1430 Tulane Avenue, New Orleans, Louisiana.
[25] 1430 Tulane Avenue, New Orleans, Louisiana.

of antibiotics, usually penicillin, together with correction of fluid and electrolyte balances and restoration of the hematocrit to normal. With this systemic treatment, there was careful protection of the local lesion by means of proper splinting or by traction and aspiration of the local abscess, followed by instillation of the appropriate antibiotic into the abscess cavity.

The number of patients seen yearly varied little and the usual bone involvement was encountered, with the femur and tibia involved in 102 cases. *Staphylococcus aureus* was isolated in 84 per cent. of the lesions; a number of rather unusual bacteria were isolated from local lesions, such as *Neisseria meningitidis*, Salmonella type B, *Treponema pallidum*, *Aerobacter aerogenes*, and Enterococcus.

Antibiotic-sensitivity determinations revealed that resistance to penicillin had increased from 6.3 per cent. as reported in 1949 to 35.6 per cent. in those patients seen since 1949. Chlortetracycline (aureomycin) resistance and oxytetracycline (terramycin) resistance were encountered in 45 per cent. of the strains of staphylococci tested; 21 per cent. were resistant to chloramphenicol.

There was one death in the series (a mortality rate of 0.6 per cent.).

When the results were evaluated according to the amount of residual bone scar, good or excellent results were obtained in 72.2 per cent. of the patients, fair results were obtained in 19.1 per cent., and poor results were obtained in 8.3 per cent. There was an increase in the fair and poor results in the patients treated since 1949. They felt that this was accounted for by the changes in antibiotic sensitivity, the lack of attention to the therapeutic details (such as aspiration of the local lesion and the protection of the local lesion in plaster), and an attitude of complacency as to the seriousness of osteomyelitis and its potential dangers.

Dr. Donald McNeil[26], in discussing this presentation, admitted the important part played by antibiotics in the treatment of osteomyelitis but believed surgery should not be relegated to the background. He stated that, in his opinion, early surgery prevents undue bone destruction with the formation of sequestra as the result of ischaemia.

Experimental Studies on Bone Preservation and Metabolism. Dr. Robert D. Ray[27] and Dr. Roscoe S. Mosiman[28] reported several recent experimental studies on bone preservation and bone metabolism carried out under grants in aid from the National Institute of Health and the Atomic Energy Commission.

The first series of experiments dealt with the preservation of bone at low temperature. The criteria for viability were growth of fibroblasts from tissue cultures of the preserved bone, production of alkaline phosphatase, a change in the pH of the culture medium, and the histological appearance of new bone on section. By means of the technique developed by Audrey Smith for the preservation of erythrocytes, femora from eighteen-day-old rat embryos had been dehydrated in glycol and had been frozen slowly to −78 degrees centigrade. They were subsequently stored at this temperature for periods of as long as three months. Viability was demonstrated by means of tissue cultures according to the criteria described. Cancellous human bone was also preserved in a similar fashion for shorter periods of time. Attempts to demonstrate viability of bone quickly frozen by the usual bone-bank technique were unsuccessful.

The second series of experiments concerned the comparative turnover of salts in dead and living bone. Two parallel tissue cultures of cancellous rat bone had been set up. One culture had been killed by rapid freezing and thawing. A culture medium containing a trace amount of radio-active strontium (Sr^{89}) had been added to both, and they had been incubated at 37 degrees centigrade for ten days, following which the uptake of Sr^{89} by the bone was measured. The uptake of Sr^{89} was found to be the same for both living and dead bone. In contrast to this, when the bone had been made radio-active by injecting Sr^{89} into the rat before the bone for culture had been removed, mobilization of strontium was much more rapid from the living culture than it was from the dead bone.

The results of this experiment suggest that, when the organic matrix is present, cellular metabolism is not essential for the calcification of the matrix; the cells play an important role in the mobilization of inorganic salts from the matrix. These findings also suggest that in aseptic necrosis of bone, increased density, as observed by x-ray, is actual as well as relative. Dead bone takes up salts by diffusion from surrounding tissue fluids, while in all probability salts are simultaneously mobilized from the surrounding living bone. Finally, these studies suggest that the uptake of radio-active isotopes by bone is not an accurate indication of bone viability.

Dr. Donald E. King[29], in discussing this very extensive and complicated laboratory procedure, speculated upon the importance of being able to determine at the time a surgical procedure is performed whether avascular necrosis is present. He spoke of the various attempts clinically to use radio-active isotopes to determine this state in the past; these had not resulted in very startling findings. In light of Dr. Ray's experiments which showed that bone obviously dead was capable of absorbing radio-active strontium to nearly the degree that living bone was, he asked the question whether these uptake studies might actually be the answer in determining, at the clinical level, whether aseptic necrosis is present.

[26] 1339 44th Street, Sacramento, California.
[27] University of Washington School of Medicine, Seattle 5, Washington.
[28] University of Washington School of Medicine, Seattle 5, Washington.
[29] Stanford University Hospital, San Francisco, California.

The Viability of Preserved Bone. Dr. S. L. Haas [30] reported a study of the viability of preserved bone. The report was based on work done in 1922, at which time it was found that a fractured bone, when buried in muscle, exhibited the same inherent tendency to unite as does bone in its normal environment. It was also reported that either the periosteum or the endosteum are essential for this union to occur; when both are absent, no union can take place. A fracture in a boiled bone showed no evidence of proliferation or tendency to unite. If one-half had been boiled and the other half had been normal, union took place between the two halves when they were implanted in muscle.

A study was also made on the viability of bone under physical conditions of exposure to various temperatures and in different types of media. Bone fragments which had been allowed to remain in a sterile bottle showed evidence of viability up to a period of nineteen hours when they were transplanted into muscle. When bone fragments had been placed in salt solution, there was no increase in the time period. If the fragments had been placed in the refrigerator at 5 degrees centigrade, there was evidence of viability up to five days.

Bone which had been kept in homologous serum showed only slight proliferation at the end of two days of preservation at a temperature of 5 degrees centigrade. When the fragments had been kept at −30 degrees centigrade, there was no evidence of proliferation or of regeneration after they were implanted in muscle.

The fractured bone which had been immersed in autogenous serum at 5 degrees centigrade showed a little more viability than that which had been placed in homologous serum, as evidenced by a little endosteal proliferation at the end of six days. When bone had been subjected to a temperature of −30 degrees centigrade, there was no evidence of active proliferation.

Fragments of bone which had been placed in whole blood at 5 degrees centigrade showed evidence of osteogenesis up to a period of ten days; fragments which had been placed in whole blood at −30 degrees centigrade showed only a slight proliferation on the surface.

Bone which had been preserved in citrated blood at 5 degrees centigrade for as many as eleven days showed definite proliferation between the fragments in muscle. If the fragments had been placed in citrated blood at −30 degrees centigrade, up to seven days, there was a minimal response about the Haversian canals and ends of bone. After longer periods of time, there was no response.

Fracture fragments which had been placed in agar agar at 5 degrees centigrade up to seven days showed a small amount of proliferation. Fracture fragments which had been placed in agar agar at −30 degrees centigrade showed very limited new-bone formation about the Haversian canals, but there was none at the bone ends.

Bone fragments which had been subjected to the quick-freeze process showed no evidence of osteogenesis and had the appearance of dead bone.

Specimens of bone which had been removed for microscopic examination before transplantation in the various experiments showed varying types of cell structure. The response of similar fragments when transplanted into muscle did not always show the same degree of activity as that which had been expected from their appearance on microscopic examination. Cellular appearance, therefore, is not a definite criterion of the viability of particular cells.

Dr. Haas concluded that preservation of bone in citrated blood at 5 degrees centigrade assured the longest period of viability and the ability to achieve active osteogenesis within the graft. The longer the period of preservation, the less was the activity of the osteoblastic cells.

Autogenous serum did not serve as a good preservative medium for a graft. Quick freezing destroyed the living cells of the graft. An autogenous bone graft, used at the earliest opportunity, gives the best chance of contributing the necessary osteoblastic factors required of a graft of bone.

Dr. Douglas Toffelmier [31], in discussing Dr. Haas' paper, indirectly confirmed the statements relative to a quick-freeze graft by describing the poor results obtained in using such material in the Navy.

Spine Fusion in the Treatment of Lesions of the Nucleus Pulposus. Dr. Frederic C. Bost [32]. No abstract submitted.

Friday, October 15, 1954

The Oblique Rotational Osteotomy. Dr. T. Gordon Reynolds [33] presented a method of correcting angular and rotational deformities of the extremities by an oblique rotational osteotomy which favors postoperative union by permitting the cut surfaces to remain in apposition. A precise geometrical formula was presented which had been devised in order to obtain the slant of the osteotomy, as well as its relation to

[30] 450 Sutter Street, San Francisco 8, California.
[31] 354 21st Street, Oakland, California.
[32] 384 Post Street, San Francisco 8, California.
[33] 1727 New Jersey Street, Los Angeles 33, California.

the actual angle or bowing, the plane of the deformity or angulation, and the rotational deformity. He pointed out the fact that ordinary examination of anteroposterior and lateral roentgenograms will frequently give erroneous conceptions as to the true rotation of the bone; frequently the surgeon finds himself in trouble by performing osteotomies from visual inspection only. He showed a method of projection by a drawing on the anteroposterior and lateral roentgenograms; by this means the angles to be corrected can be accurately determined with the use of a wax pencil and ruler. The principle involved in the oblique rotational osteotomy is as follows: If the rotational deformity is greater than the angular, the osteotomy is done relatively transversely. Conversely, if the angular deformity is greater than the rotational, the osteotomy will be done at a more acute angle. If the two are the same, the osteotomy will be done at about 45 degrees. Even with the use of the geometrical formula, he recommended that a model be made, in wax or in some similar material, of the part to be operated upon so that the solution could be visually represented prior to surgery.

Dr. Leo S. Lucas [34], in discussing this paper, complimented the author on his mathematically sound theory but expressed some doubt whether the average orthopaedic surgeon would have the necessary material on hand to do such a specific operation. He endorsed Dr. Reynold's view that a good correction is essential in the adult, whereas in children, the correction need not be too exact. In children, he preferred to use an M or slot-shaped type of osteotomy which gives good correction. This procedure is self-locking and allows bone-to-bone contact of the cut surfaces. He is in hearty agreement with Dr. Reynolds that, even when things are planned geometrically, it is wise to make a model of the procedure prior to surgery.

Tibial Plateau Fractures. Dr. Mason Hohl [35] had made a study of the records and roentgenograms of 726 tibial plateau fractures from the Los Angeles County Hospital and the Veterans Administration Hospital, Los Angeles; from this investigation he had evolved a classification in which displaced fractures of the tibial plateau were divided into the local or central depression type (48 per cent.), the total depression type (20 per cent.), and the split type (7 per cent.). Undisplaced fractures totaled 25 per cent. of all fractures of the tibial plateau.

A follow-up study had been carried out on 227 patients with fractures; 85 per cent. of these were seen by Dr. Hohl. All patients were followed from two years to thirteen years.

The results were graded on an anatomical and functional basis. An acceptable anatomical result required that there have been reduction of the fracture as seen by roentgenogram, minimal valgus or varus deformity, or no deformity, and no degenerative joint change. An acceptable functional result required that there be 90 degrees of flexion or more with good strength and endurance. A slight increase in lateral mobility or of intermittent aching was allowed as acceptable. An undisplaced fracture was one which had three millimeters' displacement or less as seen by roentgenogram.

Anatomical and functional results were acceptable in 93 per cent. of the patients. The author emphasized that he believes most fractures were treated too long in the cast and that active motion at the knee could usually be started in one month. The local or central depression group of fractures included those with comminution and depression of the articular surface. Results of the follow-up revealed 98 per cent. unacceptable anatomical results in patients not operated upon, with valgus deformity in 40 per cent. The patients operated upon showed significantly better anatomical results. Acceptable functional results in this group were obtained in 76 per cent. In patients with depressions of over one centimeter, only 54 per cent. of the results were acceptable when the patients had been treated nonoperatively; no improvement in the functional results was noted following surgical elevation. Surgery should be considered in younger patients and in women, in whom appearance is important, but it should be realized that the function of the knee is not likely to be improved.

It was recommended that, when open reduction is used, internal fixation or bone-grafting should be sufficiently secure to allow active motion in one month.

Fractures classified as total depression fractures included those with depression of an intact plateau and with the fracture line in the region of the tibial spines. Forty-seven patients had been followed. Varus or valgus deformities were common. However, in these patients, acceptable functional results were obtained in 79 per cent.

Frequently manipulation under anaesthesia and the use of skeletal traction and molding will permit adequate reduction; if these fail, open reduction with secure fixation should be used.

Fractures classified as true split fractures included those with little or no articular depression but with lateral or medial displacement of a portion of a condyle. Nineteen patients had been observed. In nine of the fourteen acceptable anatomical and functional results were achieved. The patients with unacceptable results had been treated in the cast for five months with resultant loss of motion and pain.

Dr. Hohl advised open reduction and internal fixation of split fractures which had been displaced eight millimeters or more in order to allow early active motion.

[34] 1922 N. W. Johnson Street, Portland, Oregon.
[35] 9730 Wilshire Boulevard, Beverly Hills, California.

Preliminary Report on Transfixion by Kirschner Wire for Fractures and Non-Union of the Carpal Scaphoid. Dr. Ernst Dehne [36] and Dr. Robert Feighny [37] presented a series of twenty-three fractures of the carpal navicular (scaphoid) of which nine were fresh fractures, eleven were fractures with established non-union, and three were fractures with dislocation of the lunate. Their method of treatment was transarticular fixation of the carpal navicular, with immobilization of the wrist and forearm in plaster-of-Paris. They used a No. 52 Kirschner wire. This was passed through the thenar eminence, engaging the volar aspect of the greater multangular and passing through both fragments of the navicular and through the distal end of the radius, the wrist being held in slight radial deviation and dorsiflexion. The wire was buried subcutaneously and plaster immobilization was continued until definite roentgenographic demonstration of solid union was seen.

They drew no definite conclusions relative to the outcome of the nine fresh fractures so treated. In the fractures associated with retrolunar dislocation, two of the three required open reduction. All were complicated by aseptic necrosis of the proximal fragment of the navicular. However, all showed evidence of revascularization and one demonstrated complete bony union at seven months. The others progressed favorably.

In the six fractures with aseptic necrosis, revascularization and union occurred. In the eleven fractures with non-union definite roentgenographic evidence of healing was demonstrated within one to three months. Migration and breakage of the wires occurred in 50 per cent. of their patients. This indicated that skin-tight casts which included the distal joint of the thumb failed to provide complete immobilization of the wrist.

Dr. A. B. Sirbu [38], in discussing the report, supported the thesis that there is much to be desired in the treatment of fractures of the carpal navicular; even the present method of prolonged plaster immobilization is apparently not efficient. He compared the authors' surgical approach with that of McLaughlin who immobilizes the fragments by means of a lag screw and allows immediate active motion. The technical difficulty of the procedure presented, together with slippage and breakage of the wire requiring additional operation for removal, may be efficiently used in military service, but he doubted its practicability in civil practice. However, he felt the report has demonstrated that more perfect immobilization will result in favorable osteogenesis even in cases of frank non-union and aseptic necrosis. He felt that further investigation should be encouraged in this field.

Upper-Extremity Amputation Surgery and Prosthetic Prescription. Dr. Robert Mazet, Jr.[39], Dr. Craig L. Taylor [40], and Dr. Charles O. Bechtol [41] emphasized that "sites of election" in amputation surgery of the upper extremity have been dictated in the past by prosthetic considerations. The Prosthetic Training Center at the University of California, Los Angeles, working under the aegis of the Advisory Committee on Artificial Limbs of the National Research Council has prescribed, made, and field-tested one or more upper-extremity prostheses for 225 patients in a four-year period. Many were for amputations through the prescribed areas.

Recent prosthetic developments have permitted fitting of functional prostheses at almost every level. Plastic materials and a thin wrist adapter laminated into the forearm socket produce a prosthesis no longer than the normal forearm for use after wrist disarticulation. Rotation is preserved. The double-pivot elbow hinge obviates slipping off of the socket in a very short below-the-elbow stump when the elbow is flexed.

Limited elbow motion may be compensated for by the use of the variable-ratio hinge. With this innovation, the socket and terminal device move through an arc twice that which the stump describes.

The outside-locking elbow hinge permits the fitting of elbow-disarticulation amputees with a normal-length arm section. Retention of the humeral head permits a firmer grip of the prosthesis on the shoulder, and slipping is minimized.

By reason of the successful fitting of a number of persons whose amputations were done in the so-called undesirable areas, it was contended that the concept of "sites of election" in upper-extremity amputations is obsolete. Amputation surgery of the upper extremity should be directed toward all possible length in all areas. Prosthetic considerations need not dictate the amputation site. Physical aspects, such as skin coverage, adequacy of circulation, good innervation, and function of the part to be saved, should be the determining factor in the decision as to the level of amputation.

Functional prostheses are available for almost all types of upper-extremity amputations. Prescription of the prosthesis which is best suited to the individual requirements of the patient and his particular amputation is the privilege of the surgeon. This cannot be delegated.

The surgeon should share the responsibility for amputee rehabilitation with the other members of the prosthetic team. However, he is the captain of the team. His responsibility to the patient does not terminate with wound healing. It continues through the period of rehabilitation. He must see that the amputee, aided

[36] Letterman Army Hospital, San Francisco 21, California.
[37] Letterman Army Hospital, San Francisco 21, California.
[38] 450 Sutter Street, San Francisco 8, California.
[39] Veterans Administration Hospital, Los Angeles 25, California.
[40] University of California at Los Angeles, Los Angeles 24, California.
[41] 789 Howard Avenue, New Haven 4, Connecticut.

by the therapist trainer, obtains maximum function from his individually prescribed prosthetic arm. The surgeon must, with cooperation from other team members, supervise the adjustment of the patient to his handicap and direct the restoration of the patient to social and economic independence.

DR. GEORGE BEATTIE [42] discussed the report and re-emphasized the statements of Dr. Mazet and his associates that the prosthesis must be fitted to the stump and not the stump to the prosthesis. He made this statement on the basis of his experience at the United States Naval Amputation Center, Oakland, and at the Naval Hospital in Philadelphia. By the use of such methods, reamputation surgery is avoided. Better function is usually achieved by longer stumps. He urged that orthopaedists acquaint themselves more completely with the armamentarium now available so that they will no longer be totally dependent on the prosthetist.

A Study of Dislocations of the Subtalar Joint. DR. THOMAS B. SCANLON [43], DR. JOHN J. LOUTZENHEISER [44], and DR. VICTOR DILLON [45] discussed in detail dislocations of the subtalar joint which may result in drastic consequences, if they are not immediately recognized and promptly treated. They added eight documented dislocations to the literature in which 376 had been reported previously. They subdivided subtalar dislocations into four groups, depending upon the direction in which the other tarsal bones were displaced in relation to the talus. They defined a subtalar dislocation as one in which the talus remains in normal position between the two malleoli and in which all the other bones of the foot are dislocated in relation to the talus but retain their normal relationship to one another. The various methods of closed reduction which had worked best in their hands were described and they stressed the importance of early reduction before the onset of circulatory changes and post-traumatic oedema. They reserved surgery for irreducible injuries only. Subtalar fusion or triple arthrodesis was recommended as astragalectomy had given poor results. One subtalar dislocation resulted in amputation. In their series, the longest period of follow-up was seven and a half years; the shortest period was two months. One open operation had been performed. No aseptic necrosis of the talus had been noted. Even the patients with the best results had some disability of a permanent nature due to the ligamentous damage which had occurred. If there had been an accompanying fracture of the talus, more disability was present than in those dislocations without fracture of the talus.

In the discussion DR. FRAZER L. MACPHERSON [46], although he agreed that this is a relatively rare traumatic entity, pointed out that there are a considerable number of such dislocations which are seen by individual surgeons and which are not reported. He contrasted the difference in prognosis between the dislocation without fracture and the dislocation in which fracture of the talus accompanied the injury. He said that this latter injury is relatively common, particularly in the military service among aviators. The lack of aseptic necrosis in the pure dislocation was noted in contrast to the relative frequency of the complication following fractures of the body of the talus. Dr. MacPherson attributed the necrosis to damage of the blood supply resulting from the fracture. He described the circulation of the talus which he believes is carried primarily in the talonavicular ligament from branches derived from the anterior tibial artery. Circulation finally enters the bone through nutrient vessels. Such perforating vessels have not been found in any of the other ligaments attached to the talus, and it is his belief that the preservation of this blood supply is the probable answer for the small amount of aseptic necrosis found in this particular injury.

Review of Four Hundred Cases of Congenital Dysplasia and Dislocation of the Hip. DR. WILLIAM A. CRAIG [47], DR. JOSEPH C. RISSER [48], and DR. WARREN G. KRAMER [49] had reviewed 188 cases of congenital dysplasia and hip dislocation on the service of the Los Angeles Orthopaedic Hospital from 1918 to 1950. As a result of these observations, they had made certain alterations in their method of treatment for these conditions. The time interval was too short to permit an evaluation of these changes. They defined congenital dysplasia as a condition involving the hip joint in which, as seen by x-ray, there is an increased acetabular angle and retarded development of the femoral head and of the ipsilateral pelvic bones. Dysplasia with subluxation includes, in addition, lateral and upward displacement of the femoral shaft; the femoral head is still below the acetabular limbus. In dislocation the femoral head appears to be above the acetabular limbus. In this series there were fourteen cases of simple dysplasia, sixty-four cases of dysplasia with subluxation, and 111 cases of dislocation. Of the cases of simple dysplasia, 71 per cent. were bilateral; of the cases of dysplasia with subluxation, 70 per cent. were bilateral; and of the cases of dislocation, 48 per cent. were bilateral. It was their conclusion that cases of simple dysplasia which are seen early need no reduction; treatment in such cases is simple and the results are very near normal.

[42] 3011 Telegraph Avenue, Berkeley 5, California.
[43] St. Mary's Hospital, San Francisco, California.
[44] 2020 Hayes Street, San Francisco 17, California.
[45] 490 Post Street, San Francisco 2, California.
[46] 233 A Street, San Diego 1, California.
[47] Los Angeles Orthopaedic Hospital, Los Angeles, California.
[48] 2637 East Washington Street, Pasadena 7, California.
[49] Los Angeles Orthopaedic Hospital, Los Angeles, California.

In the cases of dysplasia with subluxation or dislocation, there were poor results in about 70 per cent, because of the development of focal or generalized avascular necrosis or of resubluxation due to adduction contractures or a combination of the two. In order to prevent the occurrence of vascular changes, the dislocation should not be reduced if adductor tightness is present. All subluxated or dislocated hips should be gradually stretched until 90 degrees of abduction has been obtained, preferably in the flexed position. The cause of the resubluxation is always adductor tightness. To prevent limitation of motion, the patient should sleep in a widely extended position of abduction or the frog-leg position until the hip is normal. The patient should walk in abduction until the femoral tear-drop distance remains normal, even in the adducted position, and the acetabular index is less than 20 degrees. A plea was made for gentleness in treating patients with subluxated and dislocated hips, for the viability of the femoral head is at stake; a hip without a femoral head is a tragedy. They advised following the patient until growth has been completed; during this time a full range of abduction should be maintained.

Dr. J. R. Schwartzmann [50], in discussion, agreed that treatment of simple dysplasia usually gives uniform results, but doubted the need of any treatment provided the patient is intelligently watched over for a sufficient period. He spoke of the unreliability of depending upon x-ray studies alone as frequently in surgery an acetabulum previously diagnosed as inadequate may disclose sufficient cartilage to be adequate, although calcification has not yet been completed. He agreed that, in subluxation, a certain percentage of poor results is to be expected, but he recommended treatment of the individual patient rather than the application of the same general principles to all patients. He had found other complications besides aseptic necrosis of the femoral head, such as recurrent dislocations, limited motion, and painful dysfunction. These factors had not been evaluated in the report presented. He expressed doubt whether the adductors are the main cause for the difficulty in reduction and subsequent complications. The adherence of the psoas tendon to the inferior capsule, as demonstrated recently by Italian orthopaedists, should be given more consideration. The principle of the use of extreme gentleness throughout treatment was strongly endorsed, but he called attention to the fact that the use of fixed splints may allow the child to place as much stress on the femoral head as one can do by the so-called bloodless reduction. Preliminary traction with the hip in extension will efficiently stretch all shortened tissue (not the adductors alone) and allow subsequent reduction with a minimal amount of trauma.

Paralytic Scoliosis. Dr. J. Mayfield Harris [51] and Dr. Wallace Lyall [52] recounted their experiences in the Scoliosis Clinic at the Rancho Las Amigos Poliomyelitis Center at Honda, California. It was stressed that any child with anterior poliomyelitis, no matter how slight, is a potential scoliotic cripple and that all scoliosis, regardless of cause, tends to follow a definite pattern. Most surgeons are only interested in the deformity and neglect the other and equally important physiological dysfunctions which arise with the spinal alterations. Diaphragmatic excursion, preservation of respiratory volume, and avoidance of altered circulation are equally important. They advocate the use of corrective plaster jackets applied by the various accepted methods. These should be changed frequently enough to conform with the growth of the child and to hold the correction of the deformity which has been obtained. Their aim is to permit management of the three curves at once, with centering of the cervicothoracic junction over the lumbosacral junction, without materially increasing any of the curves involved. A certain number of patients required spine fusion, but this should be reserved for those in whom the deformity cannot be controlled by conservative measures. The ideal time for spine fusion seems to be when the patient has achieved maximum growth. In a certain number of patients, however, in whom the deformity cannot be controlled by conservative methods, fusion must be done regardless of the age of the patient.

Dr. Arthur Holstein [53], in discussing this paper, brought out the fact that some definite principles have been evolved with known success in the treatment of paralytic scoliosis in the lumbar area, with pelvic tilt. He particularly referred to the fascial graft originally advocated by Dr. Charles L. Lowman. Dr. Holstein emphasized that the pelvis should be balanced before final stabilization is considered in this area. Referring to scoliotic curves resulting from paralysis in the thoracic area, he said it is his belief that, up to the present, successful operative procedures have been lacking. Therefore, the contribution of the method of treatment reported by Dr. Harris and Dr. Lyall, which seems to decrease the thoracic curve and to improve the vital capacity of the patient, is a definite contribution to the treatment of paralytic scoliosis.

Congenital Scoliosis: An Analytical Study of Its Natural History. Dr. E. L. Billing [54] reported a study based on the observed roentgenographic changes in a series of fourteen hospital patients with congenital scoliosis. The period of observation had been variable, the longest being seventeen years. Some of the patients are still under observation.

From this study he drew the following conclusions:

[50] 2430 East Elm Street, Tucson, Arizona.
[51] 1200 North State Street, Los Angeles 33, California.
[52] 1200 North State Street, Los Angeles 33, California.
[53] 3011 Telegraph Avenue, Berkeley 5, California.
[54] University of California Medical Center, San Francisco, California.

1. Lateral curvatures resulting from a single hemivertebra are severe, usually being less than 45 degrees. When more than one hemivertebra is present, the deformity is less if they occur contralaterally and greater if they occur ipsilaterally.

2. Scoliosis due to hemivertebra does not progress beyond that which can be attributed to growth of the hemivertebra. This was illustrated by the use of a theoretical growth diagram.

3. The curvature, resulting from a hemivertebra, is usually less than the wedge of the hemivertebra itself. This tendency to decrease the curvature probably results from differential epiphyseal-bone growth of the contiguous vertebrae.

4. Conservative treatment, consisting in postural exercises designed to aid in attaining compensation, is adequate treatment in uncomplicated cases if one is willing to accept a moderate deformity.

Dr. Arthur Holstein[53] brought out the points that this condition is relatively rare and that few people have the opportunity to study a sufficiently large series to draw concrete conclusions as to the prognosis. Such a series was available to Dr. Billing. Dr. Holstein suggested, if other orthopaedists would forward their files on the occasional cases which come under their observation to Dr. Billing, a much larger series might be available for analysis, with resulting increased certainty as to the prognosis. He stressed the point that the discussion of the prognosis in these patients was the most important portion of the paper. It was emphasized that the curves do not go into decompensation, that they are never severe, and that they tend to correct and to compensate themselves relatively rapidly above and below the lesion. Treatment by conservative measures only seems indicated and the end result usually reveals a patient with good general spinal alignment.

Femoral-Head Replacement Prostheses. Dr. Bernard N. Becker[55] had critically analyzed the results in sixty-eight insertions of femoral-head prostheses during two years' experience at the Los Angeles County Hospital. Pertinent references to the literature and comparisons with previously published results were given, including a short history of the articular prosthesis. The author had personally examined all but four of the surviving patients; there was a minimum follow-up period of one year. The patients were predominantly Caucasian females, with an average age of seventy-three years. The acrylic Judet prosthesis had been used in fifty-four patients, and in the remainder an Eicher or Roger Anderson intramedullary type had been inserted. The patients were grouped by diagnosis into three major categories: twenty-four patients with fresh intracapsular fracture of the femoral neck, twenty-seven patients with unsuccessful hip nailing, and thirteen patients with arthritis. The surgeons were members of the Attending Staff and the Resident Staff. The average time of operation had been 115 minutes, and the Gibson incision had been used most frequently. No significant correlation with complications or results was obtained from an analysis of the incision, postoperative management, or variations in surgical procedure. There were no deaths from anaesthesia; but anaesthetic morbidity was very high, and 16 per cent. of the patients experienced serious cardiovascular complications. Most of the surgical complications were of a mechanical nature and included six fractures of the femur. All the fractures occurred when an intramedullary prosthesis had been inserted; the fractures were associated with osteoporosis, contractures, difficulty in reducing the head, or inadequate size of the medullary canal. In two instances each, the prosthesis fitted poorly in the acetabulum, fell loosely into the previous nail tract, or was in a position of extreme varus. The surgical mortality was 18 per cent. Three patients died in the early postoperative period and nine suffered a progressively worsening course and expired within a few weeks. Half of the patients had some early postoperative complication; infections and dislocations were common. Many of the miscellaneous difficulties were attributed to faulty postoperative care or to poor selection of the surgical candidate, rather than to the prosthesis itself. This cannot be said of the seventeen late postoperative complications. Paracapsular calcification and excessive movement of the prosthesis with bony resorption occurred frequently. Superior migration and fracture of the prosthesis were also recorded. In treatment of these many complications, fourteen patients underwent sixteen subsequent operations. Five prostheses were removed for gross infection with osteomyelitis. Only one patient had a satisfactory result following dislocation.

The results in this series were very discouraging: 14 per cent. were rated *good;* 14 per cent. were rated *acceptable;* and 72 per cent. were rated *failure*. The ability to walk without support with mild pain and no noticeable limp was required for the result to be rated *good*. Use of occasional support with moderate pain on prolonged use and a slight limp was rated *acceptable*. Allowances were made in some of the arthritic patients when the goals set before operation had been obtained. Most of the failures were due to death or some other major complication. In the twenty-four fractured hips which had been treated primarily with a prosthesis, a failure rate of 79 per cent. resulted. Slightly better results were obtained in arthritic patients and in a small number of patients who had had an Eicher prosthesis inserted. In the entire series, only nine patients had good results.

Dr. Becker drew from his study the following conclusions:

1. Resection-reconstruction should not be undertaken lightly. It is poorly tolerated and is not advised for use in the elderly patient without careful consideration of the risks involved.

[55] Los Angeles County Hospital, Los Angeles, California.

2. There are many mechanical complications incidental to the insertion of a femoral-head prosthesis. Some of these are avoidable by careful evaluation of the status of the acetabulum and the femoral neck.

3. Infection remains a serious problem. Until the incidence of infection has been reduced substantially this procedure cannot be fully recommended.

4. The use of an intramedullary type of prosthesis will increase the likelihood of fracturing the femur. This is especially true when osteoporosis or contracture is present.

5. Superior migration, acetabular erosion, excessive movement, and fracture of the prosthesis are fundamental problems which must be solved before a foreign body can successfully replace a living hip joint.

6. Until results improve, this procedure is not indicated in the treatment of a fresh fracture of the femoral neck.

End Results of Femoral-Head Prostheses Used in Fresh Fractures. Dr. Howard E. Fishel[46] reported the results in twenty-six consecutive patients with transcervical fracture admitted to the San Diego County Hospital and treated by the insertion of a femoral-head prosthesis as a primary procedure. One patient was only forty-nine years of age; he had a fracture-dislocation of the left hip, and internal fixation was not feasible. Except for this patient, the ages ranged from sixty-two to ninety-two years. Five were not ambulatory at the time of the accident.

Twenty of the twenty-six patients presented some complicating factor preoperatively. Six presented no significant factor relative to surgical risk other than age.

A posterolateral Gibson approach was used in all patients. A Judet acrylic prosthesis was used in the first nine, and a Roger Anderson nylon prosthesis was inserted in the remaining seventeen.

There were five operative deaths (19.2 per cent.).

Postoperative complications occurred in twelve patients (45 per cent.). These included dislocation of the prosthesis in two patients. Periarticular calcification occurred in twelve patients; it seemed to have no relation to the range of motion.

Fifteen patients are still alive. Of these, ten are walking, but only one walks without support. Nine patients are completely free from pain. This was, perhaps, the most gratifying finding.

In studying the ranges of motion, an arbitrary classification was used. Flexion-extension was considered one motion; this was true of abduction-adduction, as well as of rotation. It was found that the Judet acrylic prosthesis gave a better range of motion in most patients than did the Roger Anderson nylon prosthesis; however, it was more often accompanied by shortening.

In view of this experience, it was concluded that prostheses should not be used in the treatment of fresh fractures of the femoral neck.

Dr. Francis J. Cox[47], in discussing the two preceding papers, brought out the important fact that the reason hip prostheses are so widely used is that treatment by conventional methods has been far from satisfactory. Although the results attained by the use of the prostheses have been discouraging, he expressed the belief that the conventional nailing of high subcapital fractures of the neck of the femur gives equally poor end results with the development of non-union or, if the fractures unite, of aseptic necrosis and absorption about the nail. He expressed the belief that, following a period of experimental work, progress may eventually be made. Both technique and materials which have been found to be unsatisfactory will be discarded, more specific indications will be evolved, and the promiscuous use of prostheses will be curtailed.

Review of Results of Treatment of One Hundred Cases of Spondylolisthesis. Dr. Norris J. Wilson[48] reported a review of sixty-six cases of spondylolisthesis in the series of 100 treated on the Orthopaedic Service of the Veterans Administration Hospital, Portland, Oregon, between the years 1946 and 1954. Evaluation of the final results of treatment was determined on the basis of the patient's ability to work, freedom from symptoms, and the presence or absence of significant findings on physical examination. The results were classified as *excellent*, *good*, *fair*, or *poor*, the first two categories being considered as satisfactory and the last two unsatisfactory. The average age in the series was thirty-two years. Forty patients had been treated surgically by open operation; thirty-five had had spine fusion. The procedure resulted in failure in 24.3 per cent. of the patients. The results in 66.6 per cent. of the patients were considered to be satisfactory, and in 33.3 per cent. they were considered to be unsatisfactory. Five patients had been treated surgically by excision of the loose portion of the involved posterior intervertebral arch, according to the method described by Dr. Gerald Gill. The postoperative follow-up in these patients is less than a year; therefore, final evaluation is not possible. At the present time the results in all are apparently satisfactory. Follow-up roentgenograms have not revealed any advance in the degree of slippage. Twenty-six patients in the series had been treated conservatively. In this group satisfactory results were obtained in 42 per cent. and unsatisfactory results in 58 per cent. He concluded that the open operative approach tends to give more satisfactory results.

[46] San Diego County Hospital, San Diego, California.
[47] 450 Sutter Street, San Francisco 8, California.
[48] Veterans Administration Hospital, Portland, Oregon.

DR. GERALD G. GILL[59], in discussing Dr. Wilson's paper, pointed out that 56 per cent. of these patients had back pain and sciatic pain and that 6 per cent. had sciatic pain without back pain. He asked the question whether the other 38 per cent. with back pain alone might have had positive neurological findings. In his experience with the decompression operation, he had found that the majority of patients with symptomatic spondylolisthesis present radicular symptoms from compression. He stated that 10 to 15 per cent. of his patients had disc protrusion at the fourth lumbar interspace. He explained the good results obtained by spine fusion on the basis of limitation of motion of the loose vertebral arch of the fifth lumbar vertebra which decreased irritation of the first sacral-nerve roots and the fibrocartilaginous mass, and a decrease in the compression of the fifth lumbar-nerve root. He stated that he had had 85 to 90 per cent. excellent results following the decompression operation. He hopes for further improvement in the technique and feels results will continue to be more satisfactory. He believes that spondylolisthesis does not cause instability in the low-back area but that the symptoms are the result of nerve-root compression.

Tendovaginitis of the Extensor Digiti Quinti Proprius. DR. BERNARD J. DRURY[60] recorded his observations of a complication, the incidence of which he estimated at a rate of 10 per cent. following fractures and injuries about the wrist joint in adults. The condition has never been found in children or in young adults; its most common precipitating cause is a Colles fracture. He noted that, when active motion of the wrist joint is begun following immobilization, there may be marked persistence of pain with motion and gripping function. Swelling of the hand and wrist with limited mobility of the intrinsic finger joints is frequently found. When this clinical picture develops, he believes that careful investigation will disclose the presence of tendovaginitis of the extensor digiti quinti proprius on the dorsal aspect of the wrist distal to the radio-ulnar articulation, in the so-called fifth compartment of the wrist joint. Early recognition is important and treatment of the condition by retrograde injection of the fifth dorsal compartment to strip the tendon sheath of the extensor digiti quinti proprius relieves the condition in most patients. When the local pain has been relieved, normal mobility of the hand and wrist can be obtained by means of the usual therapeutic measures. He had found that the injection of the sheath with 1 per cent. procaine rarely has to be repeated more than two or three times. The results have been so successful that surgical intervention for freeing of the traumatic stenosis of the sheath is unnecessary.

DR. CLARENCE A. LUCKEY[61], in discussion, brought out the fact that all have seen many patients with such subjective complaints and localized tenderness, but that few have been keen enough to make a specific diagnosis. He cited the difficulty that presently has existed relative to tendovaginitis of the extensor carpi ulnaris, and he believes that this is another entity which should be considered in the differential diagnosis of localized pain in the wrist with stiffness following trauma. It would be of educational value if surgery could be performed on a few of the patients with such pain to see the exact pathological changes which exist; but, if procaine injection is so efficacious, this procedure must be of more theoretical value than of practical value.

Treatment of Severed Flexor Tendons of the Hand in Children. DR. ELMER H. THOMASSEN[62] presented a study of the results of repair of severed finger flexor tendons in children which had been made to determine the minimal age group in which reconstruction may be successful. Only children with repairs to the tendons in the area lying between the distal flexion crease of the palm and the middle flexion creases of the fingers were reviewed. The children chosen were those operated upon before the age of sixteen years at the Los Angeles Orthopaedic Hospital and in the private practices of Dr. Boyes and Dr. Wilson since 1939. The results in the very young children were compared with those in the older age group. Arbitrarily, children under four years of age were considered to be the very young.

There were forty-six grafts in forty-one patients. The results were measured by the method used by Boyes in his study in 1950—that is, the distance the digital pulp lacks when the attempt is made to touch the distal crease of the palm (or of the mid-palm) with the involved finger in its maximum voluntary flexion. Even though this method of measurement is not an index of the distance the flexor tendon slides in a small child's hand as it is in a large adult hand, it does measure, from the standpoint of function, the ability of the child to pinch, to hook, and to grasp. The results were classified as follows:

Good:	0 to ½ inch	(0 to 1.27 centimeters)
Passable:	½ to 1 inch	(1.27 to 2.54 centimeters)
Poor:	1 to 1½ inches	(2.54 to 3.81 centimeters)
Failure:	Over 1½ inches	(Over 3.81 centimeters)

Thirteen patients (76.5 per cent.) in the younger age group could flex the finger tip to within one inch (2.5 centimeters) of the mid-palm; these were considered to have had either a good or a passable result. In four (23.5 per cent.), the results were considered to be either poor or a failure. In the older age group,

[59] 516 Sutter Street, San Francisco 8, California.
[60] Stanford University Hospital, San Francisco, California.
[61] 333 North Sutter Street, Stockton, California.
[62] Los Angeles Orthopaedic Hospital, Los Angeles, California.

in seventeen (70.8 per cent.) good or passable results were obtained. In seven (29.2 per cent.), the results were poor or complete failures.

The results of secondary tendon-grafting in the younger age group compare very favorably with those in older children. The youngest patient operated upon was a sixteen-month-old female, who had severed both flexor tendons to the left ring finger three months previously. She now has a passable result, being able to flex the finger tip to within five-eighths of an inch (1.6 centimeters) of the distal crease. The longest delay in repair was seven and a half years; the result was poor.

The technique of grafting used was similar to that used by Bunnell.

If no contra-indication exists, such as longer than six to eight hours since the injury, fracture, multiple digits involved, nerve injury, untidy wounds, or limited facilities for hand work, primary repair may be attempted in this critical area. The sublimis tendon should be resected. Only the profundus should be repaired, suture-at-a-distance being used.

It is not recommended that reconstruction be delayed solely because the child is too young.

Dr. Walter Graham [14], in discussing this report, said that grafting of flexor hand tendons in children gave better results than in adults because of their natural will to use the member. He expressed certain preferences in operative technique and stressed the use of a small enough graft to reduce to a minimum adhesion formation between the graft and the pulleys.

Saturday, October 16, 1954

A New Concept of Etiology in the Management of Low-Back Pain. Dr. Roger Anderson [63] and Dr. Ivan Loughlen [64] emphasized that medical history has shown that once the primary cause of symptoms has been found, treatment need no longer be blindly groping. Evaluation of years of experience gained from conservative, manipulative, and surgical treatment of backache led Dr. Anderson and Dr. Loughlen to conclude that, in the large majority of patients with disc disease and low-back disorders, the cause of backache is pathological damage in the spinal joints. The joint symptoms in the back are like those in other joints; both lend themselves to similar diagnostic approaches and therapeutic measures.

The movement between two vertebrae is unique in that the joints constitute a tripod arrangement, there being a posterior pair and a single anterior joint. These move synchronously with every motion, be it ever so slight. The frequency of deformity, congenital and acquired, and the high incidence of arthritis in the lower lumbar joints result in non-synchronized, malfunctioning posterior joints which produce attrition of all three joints and early degeneration of the interbody joint.

Knowledge that the cause of most backache is primarily due to pathological changes in the joints makes the diagnosis and management of backache an understandable and practical procedure since the interpretation, methods of examination, and principles of treatment are the same as those in use for the joints of the extremities.

Dr. A. Gurney Kimberley [65], in discussing this paper, subscribed in general to the statement that all component structures about a degenerated area contribute to the symptom complex. He pointed out that one cannot be too dogmatic as to which is the initiating factor and which is the secondary factor resulting in the ultimate symptom of low-back pain. He stressed that posterior herniation of the nucleus pulposus is too often diagnosed; although it is one of the most common causes of sciatica, it is certainly not the only one. He warned surgeons to avoid new techniques which treat the single component only, failures being attributed to the patient and to unforseeable complications. He stated that surgeons limit their thinking by taking sides for one component or the other without a consideration of the entire problem. The value of spine fusion in these conditions should not be underestimated because of the failures which he believes to be due more frequently to the individual surgeon than to the lack of basic soundness of the operation which has stood the test of time.

Ligamentum Flavum Intrusion: A Source of Back and Radicular Disability. Dr. Homer C. Pheasant [66] again called attention to the ligamentum flavum, often discussed in the past as a cause of radicular pain and backache and, in recent years, discarded by most as a disability-producing factor. He presented a graphic anatomical description of the ligament, its attachment to the lateral articulations, and its peripheral extension into the neural canal. He accepted the statement as fact that no true hypertrophy of the ligament is possible as the substance is normally yellow elastic tissue. The ligament may cause symptoms by intrusion into the interlaminar space; this produces direct pressure. Such intrusion could be sufficient to cause a change in the longitudinal epidural veins which frequently develop varicosities. He believes that posture plays basically a most important part in intrusions of this structure and forms the basis for the resultant backache and radicular syndrome. The author stated that the condition of intrusion of the ligamentum

[63] 1319 Medico-Dental Building, Seattle 8, Washington.
[64] 1319 Medico-Dental Building, Seattle 8, Washington.
[65] 2455 N.W. Marshall Street, Portland, Oregon.
[66] 1401 South Oak Street, Los Angeles 14, California.

flavum can be demonstrated by myelography, particularly by lateral roentgenograms made with the patient prone; these show an indentation on the dorsum of the opaque column. He recommended operative removal of the ligament and, if necessary, a partial laminectomy. He expressed the opinion that postural settling of the spine is the basis for the ligament intrusion. No series of cases were cited and no follow-up report was given to substantiate this hypothesis.

Dr. Forrest L. Flashman [67], in discussing this paper, stated that he personally had not seen such a lesion and expressed the opinion that intrusion of the ligamentum flavum as a primary cause of low-back pain and sciatica probably exists very rarely.

A Transverse Anterior Approach to the Hip. Dr. J. Vernon Luck [68] described a transverse anterior approach to the hip which he had originally developed to carry out more easily his reconstruction of the hip for ununited fractures of the neck of the femur, associated with absorption of the neck and a healthy femoral head. However, the approach had proved advantageous in carrying out a wide range of operative procedures, such as arthroplasty of the hip, open reduction and pinning or grafting of fractures of the neck of the femur, replacement and fixation of slipped capital femoral epiphyses, open reductions of congenital dislocations of the hip, and insertion of upper femoral prostheses. The approach gives the view of the hip joint offered by the Hueter approach and, at the same time, the needed exposure of the trochanteric region.

After the patient has been placed on the operating table in the supine position, a medium-sized sandbag is thrust well under the buttock on the side of the operation. The medial end of the transverse skin incision lies over the femoral head. The incision is begun just lateral to the mid-point between the anterior superior iliac spine and the symphysis pubis, is directed laterally in the skin lines in or near a flexor crease of the hip, and is ended at a point lateral to the region of the greater trochanter. By the placing of the hip in slight abduction and slight flexion, the intertrochanteric area lies beneath the incision. Prior to the transverse sectioning of the tensor fasciae latae, when needed, the subcutaneous fat and skin are dissected off the fascia lata and the tensor muscle for one or two inches (2.5 or 5 centimeters) above and below the level of the skin incision. Care must be taken to identify clearly the tensor fasciae latae before it is sectioned. This can be done first by sectioning the fascia lata laterally over or distal to the trochanteric area, after which all aspects of the muscle are readily visualized. The muscle is sectioned as far distally as is compatible with easy repair. The nerve to the tensor fasciae latae enters the muscle posteriorly in its proximal one-half or one-third and is not disturbed since the transverse sectioning of the muscle is carried out in the distal one-half or preferably the distal one-third of the muscle.

After the sectioned fascia lata and tensor fasciae latae have been retracted proximally and distally, the sartorius and rectus femoris are mobilized and are retracted medially. Capsular attachments of the rectus femoris are dissected from the capsule to facilitate medial retraction. Whether or not the origin of the rectus femoris from the anterior inferior iliac spine is sectioned depends upon the extent to which exposure of the acetabulum is required by the operation. With the tensor fasciae latae completely retracted from the operative field, it is seldom necessary to section the rectus femoris for adequate acetabular visualization.

Laterally the approach, if desired, can include detachment of the glutaeus medius and glutaeus minimus with or without the greater trochanter. Actually, a medullary stem prosthesis can generally be nicely inserted without removal of the abductors or the greater trochanter. If there is need for transplantation of the greater trochanter distally, this can be carried out with ease. In more difficult insertions of medullary stem prostheses, the lateral end of the skin incision can be curved proximally for two or more inches. And, likewise, the incision in the fascia lata can be extended upward between the posterior margin of the tensor fasciae latae and the anterior margin of the glutaeus maximus. When this proximal extension is employed, it is frequently unnecessary to divide the tensor fasciae latae transversely.

If, in addition to exposure of the hip, the exposure of the upper third of the femoral shaft is needed, the lateral end of the transverse skin incision and fascia lata incision are curved distally and are carried as far as needed down the lateral aspect of the upper portion of the thigh.

When only the hip joint proper is to be opened and explored, the transverse skin incision is not carried so far laterally, and it is not necessary to section the tensor fasciae latae.

As in the Hueter and Smith-Petersen approaches, care is taken not to injure the lateral femoral cutaneous nerve. The femoral vessels lie beneath the medial end of the skin incision and are not exposed.

The skin incision, directed as it is in the skin lines, heals in a splendid manner with very little scarring. It does not have the tendency to a spreading scar which generally characterizes incisions directly across skin lines.

The transverse anterior approach has withstood the test of a thorough trial period and its advantages over other approaches have been clearly evident. The approach is direct, versatile, simple, and relatively bloodless. No ill effects whatever have been identified with sectioning the tensor fasciae latae.

Dr. Leroy C. Abbott [4] expressed interest in the anterior transverse approach to the hip joint and

[67] 1301 Spring Street, Seattle 4, Washington.
[68] 1930 Wilshire Boulevard, Los Angeles 5, California.

reminisced on its use in his experiences in the First World War. He questioned whether one should too lightly evaluate the function of the tensor fasciae latae and believed a careful evaluation of postoperative gait might be revealing.

AMERICAN COLLEGE OF SURGEONS
THE FORUM ON FUNDAMENTAL SURGICAL PROBLEMS

Orthopaedic Section

PREPARED BY LEE T. FORD, M.D., ST. LOUIS, MISSOURI

The Forum on Fundamental Surgical Problems relating to orthopaedic surgery of the Fortieth Clinical Congress of the American College of Surgeons was held in Atlantic City, New Jersey, on Wednesday, November 17, 1954. Dr. J. Albert Key presided. Summaries of the papers presented follow:

The Healing of Fractures in Experimental Animals Fed a Protein-Free Diet. A Preliminary Report. DR. JACK K. WICKSTROM [1], DR. ROBERT HUTCHINSON [2], and DR. EDWARD T. HASLAM [3] reported an experimental study on the healing of fractures in 100 white rats. The rats were divided into three equal groups. One group had been fed a normal laboratory diet, one had been fed a high-protein diet, and the third had been fed a fortified protein-free diet. All of the rats were adult males.

After the animals had been fed one of the diets for thirty days, a longitudinal slot was made in the cortex of the right tibia with a 1-millimeter saw blade and a closed fracture was produced in the right humerus. The animals were studied with reference to their nutritional state and the rate and manner of healing of the fractures.

In the rats on a low-protein diet, there was a loss in weight, a low hemoglobin level, and a low protein level. Slight osteoporosis and slight thinning of bony cortices also developed. The bone marrow of the rats in this group was considered less cellular than that in the rats in the other two groups.

The animals were sacrificed at varying intervals, and the manner and rate of healing was studied grossly, microscopically, and by x-ray. In addition seventy-eight of the 200 bones operated upon were tested mechanically for breaking strength at the fracture site by means of an impact tester.

The authors concluded that, although the protein-free diet resulted in callus formation of a poorer quality than that in the controls (as shown by x-ray), the breaking strength of the intact bones was essentially the same as that in other rats when the bones were of the same size. Smaller bones broke with less impact than the larger bones in each group. The rats on a protein-free diet became ill, lost weight, and some died. Their bones fractured with greater ease than did bones in the other two groups. In them bone healing was slower than that in the other groups; but union eventually took place. Microscopically they could see no difference in the callus.

Upper-Extremity Amputation Surgery and Prosthetic Prescription. DR. ROBERT MAZET, JR. [4], DR. CRAIG L. TAYLOR [5], and DR. CHARLES O. BECHTOL [6] summarized their experiences with the manufacture, fitting, and use of upper-extremity prostheses in 240 patients, nineteen of whom were bilateral amputees. Amputations had been carried out at almost every conceivable site in the upper limb. The so-called "sites of election" were not necessarily adhered to. They stated that a prosthesis can be fitted to an upper-extremity stump at almost any level. A wrist adapter made of thin plastic materials can be fitted into a forearm socket to produce a prosthesis for use after wrist disarticulation. This is no longer than the normal forearm and hand and preserves rotation. For a very short forearm stump, a prosthesis with a double-pivot elbow hinge which will not slip off the short stump in flexion can be used. If an elbow joint has limited motion, a variable ratio "step-up" hinge may be used to compensate and to produce a normal range of flexion and extension in the prosthesis. By means of an outside-locking elbow hinge, an elbow-disarticulation amputee may be fitted with a prosthesis with the arm section of normal length.

The authors stressed that there are no longer "sites of election" in the upper extremity. However, as much length as possible should be saved. They feel that the surgeon should be captain of the team which prescribes, manufactures, fits, follows, and services the prosthesis—or in other words, he should play a leading role in the rehabilitation of the amputee.

[1] 1430 Tulane Avenue, New Orleans 12, Louisiana.
[2] 1430 Tulane Avenue, New Orleans 12, Louisiana.
[3] 1430 Tulane Avenue, New Orleans 12, Louisiana.
[4] U. S. Veterans Hospital, Los Angeles 25, California.
[5] University of California at Los Angeles, Los Angeles 24, California.
[6] 789 Howard Avenue, New Haven 4, Connecticut.

Freeze-Dried Arteries Used Experimentally as Tendon Sheaths. Lt. Douglas R. Koth [7] and Lt. William H. Sewell [8] pointed out that the causes of failure after tendon-grafting and repair are adhesions and scarring. Scarring arises from the paratenon rather than from the scar at the site of the tendon suture. Since it had been shown by other experimental work at Bethesda that freeze-dried arterial homografts produce less connective-tissue response than other vessel homografts, they decided to study the use of such grafts as tendon sheaths.

In one series of dogs, they sutured a freeze-dried carotid-artery graft about the extensor communis tendon. The tendon was not cut. Nineteen animals were operated upon and infection developed in three. Of the remaining dogs, excellent results were obtained in eleven. It was felt, on microscopic study, that the grafts had been completely replaced by host fibroblasts. In the control legs, adhesions about the tendon were present, but there was only slight limitation of motion. It was found that adhesions in the artery graft were located along defects in the line of suture or at the site of branches of the artery.

In a second series of twelve dogs, the extensor carpi radialis tendon was used. In one stage, the tendon was exposed and partially sectioned. Two weeks later the tendon was exposed and was found to be scarred and adherent. The tendon was freed, was repaired, and was covered with an arterial graft at the site of the defect. The animals were sacrificed at intervals from fifteen to ninety days. Good results were obtained, except in two dogs in which infection developed.

In a third series, a similar experiment was carried out in dogs, except that heterografts (arteries from calves) were used. The results in this series were poor, and firm adhesions were found in and about the artery graft.

The authors feel that the method can be used clinically in order to minimize adhesions around tendon repairs or tendon grafts. They believe that the use of freeze-dried veins might give better results; they are carrying out experiments with veins at present.

Studies on Epiphyseal Stimulation. Dr. Edward C. Percy [9] and Dr. C. Laird Wilson [10] stated that, in following up the work they reported at the meeting of the Orthopaedic Section of the Surgical Forum in 1951, they had discovered discrepancies. Therefore, they had carried out further experimental work. All experiments were done on dogs, and the tibia was used in each. Stimulation was attempted by means of the insertion of an "electrode" in both the metaphysis and the epiphysis of a growing bone. The electrode consisted of various combinations of dissimilar metals which had been fused together in the form of a battery. When the electrode was inserted in body fluids, galvanic current was generated.

In control animals, the opposite tibia was exposed and was drilled, without the insertion of dissimilar metals. In some animals, staples of dissimilar metals were used; in others, a metal plate with dissimilar screws was used. The animals were followed from three months to three years. They were allowed to run freely on a farm following surgery. In all animals, bony absorption was found about the metal and some sclerosis was seen away from the area of absorption. No marked foreign-body reactions were noted. When the epiphyseal plate had been damaged, epiphyseal shortening occurred. The greatest stimulation of growth occurred when a metal plate connected dissimilar screws. When metals were not thus joined, little stimulation of growth occurred.

In 71 per cent. of the dogs, stimulation of growth amounting to one to five millimeters occurred. This increase took place in from one to four months after the insertion of the metal; growth then remained constant.

Some experimental work had also been done on young children with limb-length discrepancies.

The authors concluded that the method is neither predictable nor reliable for the stimulation of the growth of a long bone; they stated that they had not been able to reproduce the results reported in their original paper.

Experimental Study of Polyvinyl Sponge in the Formation of New Bone. Dr. A. Morton Struthers [11], Dr. John H. Grindlay [12], and Dr. Clyde J. Dawe [13]. This paper was withdrawn.

An Experimental and Theoretical Study of Spine Stability. Dr. Donald B. Lucas [14] and Mr. Boris Bresler [15] presented an experimental study of the stability of the spine without muscular support. Using autopsy specimens, they removed the muscle attachments of the thoracic, lumbar, and upper sacral spine.

[7] Naval Medical Research Center, National Naval Medical Center, Bethesda, Maryland.
[8] Naval Medical Research Center, National Naval Medical Center, Bethesda, Maryland.
[9] Experimental Surgical Laboratories, McGill University Faculty of Medicine, Montreal, Quebec, Canada.
[10] Experimental Surgical Laboratories, McGill University Faculty of Medicine, Montreal, Quebec, Canada.
[11] Mayo Foundation for Medical Education and Research, Rochester, Minnesota.
[12] Mayo Foundation for Medical Education and Research, Rochester, Minnesota.
[13] Mayo Foundation for Medical Education and Research, Rochester, Minnesota.
[14] Department of Orthopaedic Surgery, University of California School of Medicine, San Francisco, California.
[15] Department of Civil Engineering, University of California, Berkeley, California.

They then carried out a load-testing experiment on the vertebral column after the sacrum had been fixed to a base and wires had been placed in the spinous processes and in the bodies of the vertebrae. Horizontal loads were applied in the coronal and in the sagittal plane; by means of multiple photographs, the amount of motion between each adjacent pair of vertebrae, and thus the amount of motion at each disc level, was measured for each change in load. It was found that there were no excessively mobile or immobile areas in the spine. From an engineering standpoint, they likened the behavior of the vertebral column without muscle attachments, but with intact ligamentous structure, to that of a flexible steel rod fixed in the vertical position. They noted that horizontal loads applied to such a metal rod with the top of the rod fixed can produce a curve of a C type or an S type, such as those seen in scoliosis. They theorized that scoliosis may begin in the spine in a similar manner as a "buckle" and that with growth the deformity becomes more marked.

Treatment of Comminuted Fractures of the Lower End of the Radius. Dr. John R. Moore [16]. This paper was not presented because of illness.

A Study of Experimental Trauma to the Distal Femoral Epiphysis in Rabbits. A Preliminary Report. Dr. Lee T. Ford [17] and Dr. J. Albert Key [18] reported on a study of three types of experimental trauma to the distal femoral epiphysis in a series of twenty-nine rabbits, three to four weeks of age. The animals had been followed for three to four months before being sacrificed. They were measured and x-rayed; their bones were examined grossly and microscopically. The opposite femur in each animal served as a control.

Forty-eight animals had been included in the experiment, but nineteen did not survive. Most of these were lost because of anaesthesia difficulties in the baby rabbit. There were no infections.

In the first group of eleven animals, the center of the distal femoral epiphysis had been drilled with a 1/8-inch drill through the intercondylar notch of the femur. A plug of gelfoam had been placed in the drill hole in order that bone formation might be impaired. There was an average of 0.6 centimeter (6.3 per cent.) shortening of the femora operated upon, with a minimum of 0.2 centimeter and a maximum of 1.1 centimeters. The average length of the control femora was 9.3 centimeters.

In the second group of eight rabbits a similar procedure had been carried out, with the exception that, in addition to drilling the epiphysis, a curette had been inserted in the drill hole and the entire central portion had been curetted. Gelfoam had been placed in the defect. When the animal was sacrificed, there was an average shortening of 2.1 centimeters (22.1 per cent.), with a minimum of 1.6 centimeters and a maximum of 2.8 centimeters. Control femora had an average length of 9.5 centimeters.

In the third group of ten rabbits, the center part of the epiphysis had not been disturbed and the periphery had been curetted. This resulted in an average shortening of 1.4 centimeters (14.5 per cent.) with variations from 1.0 to 2.2 centimeters. Control femora had an average length of 9.6 centimeters. More bony deformities and exostoses occurred in this group; when arrest occurred after the procedure, microscopic examination showed that a thin plate of bone had developed at the site of the epiphyseal plate.

There was no significant difference in the length of the tibiae in any animal.

It was concluded that a small portion of the center of an epiphysis can be damaged with only mild growth interference. If the peripheral portion is injured more marked growth limitation and deformity may result; if the central portion of the epiphysis is destroyed, marked growth interference will follow. Care should be taken in any surgery on children to avoid damage to an epiphysis.

Experimental Epiphyseal Lesions in Rabbits. Dr. Z. B. Friedenberg [19] and Dr. Robert Brashear [20] presented an experimental study of epiphyseal lesions in twenty-three rabbits. The lateral half of the epiphyseal cartilage had been excised. Bone wax had been placed in the defect in the cartilage in some animals in order to retard healing by bone across the epiphyseal plate; in others, no bone wax had been inserted. It was found that, in the animals in which bone wax had been used, less valgus deformity developed than that which developed in those in which bone wax had not been used. The animals were several weeks old when they were operated upon; they were sacrificed at up to ninety days after the experiment.

The insertion of the bone wax exerted a beneficial effect in that it retarded the formation of a bony bridge which would have produced an earlier fusion of the metaphysis to the epiphysis and, hence, lessened the development of valgus deformity.

Further work is being carried out along similar lines and will be reported later.

Excision of the Ankle Joint. Dr. Antonio Samson [21] reported on his clinical experience with thirteen

[16] Department of Orthopaedic Surgery, Temple University Hospital, Philadelphia, Pennsylvania.
[17] 4952 Maryland Avenue, St. Louis 8, Missouri.
[18] 4952 Maryland Avenue, St. Louis 8, Missouri.
[19] 133 South 36th Street, Philadelphia, Pennsylvania.
[20] Section on Orthopaedics, Chapel Hill, North Carolina.
[21] 401 East Boul St. Joseph, Montreal, Quebec, Canada.

complete astragalectomies which had been followed by talocalcaneal fusion. In this series there were two cases of tuberculosis and one case of osteo-arthritis of the ankle joint. Ten astragalectomies were done because of trauma or severe degenerative arthritis following trauma. In most patients severe degenerative arthritis, persistent infection from osteomyelitis, or suppurative arthritis following open fracture of the ankle was present.

The author advised that the operation be utilized more frequently than it has been; it has been almost abandoned by orthopaedic surgeons. In the majority of his patients, he obtained painless stability with good function and a fairly satisfactory appearance of the ankle and foot.

Arthrography of the Knee Joint with Water-Soluble Contrast Medium. Dr. Jean-Pierre Jean [22] noted that, in many cases of internal derangement of the knee, the conventional x-ray is unrevealing. In 100 patients, water-soluble contrast media had been used in the knee joint. He had not used air, oxygen, or nitrogen. The media which he had used were diodrast, uroken, neoiopax, diodone and umbradil. He had found that the material was absorbed from the joint in one hour. Effusion of the joint had not been a contra-indication to arthrography. He had aspirated any excess fluid and had injected 10 cubic centimeters of medium into the joint. X-rays were made immediately following massage and movement of the joint to distribute the medium. An elastic bandage was placed about the thigh to distend the joint. With a fluoroscopy spot-film device, x-rays were made in the anterior, posterior, and each oblique direction. The x-rays were made with a low voltage in order to get maximum contrast. The spot films were carefully studied for minute changes about the defect made by the meniscus. The author reported no infections or other complications; in approximately one-half of the patients in whom arthrography was followed by arthrotomy, surgery confirmed in a high percentage the findings indicated on the x-ray studies.

Posterior-Horn Tears of the Knee Cartilages. Dr. C. Laird Wilson [23] stated that it may be clinically difficult to diagnose posterior-horn tears of the knee cartilage because they usually do not produce locking of the joint. He said that, if these small posterior tears are left alone, they will eventually enlarge and produce locking. They may be associated with an intermittently painful knee with occasional effusion and atrophy of the thigh.

In a series of thirty-five patients, arthrograms were made, water-soluble media being used. Of these thirty-five consecutive arthrograms, twenty-nine indicated a tear in the posterior horn of a meniscus. Thirty patients were operated upon, and the twenty-nine positive arthrograms were confirmed. In the last patient, the operative findings were negative; again the arthrogram was confirmed.

The author advocated arthrography of the knee joint in problem cases and arthrotomy of the knee for removal of a meniscus when this study indicates a tear in a meniscus.

SOUTHERN MEDICAL ASSOCIATION
SECTION ON ORTHOPAEDIC AND TRAUMATIC SURGERY

Prepared by S. Benjamin Fowler, M.D., Nashville, Tennessee

The Section of Orthopaedic and Traumatic Surgery of the Southern Medical Association met in St. Louis, Missouri, November 8 to 11, 1954. Dr. R. Beverly Raney presided. The meeting consisted of three half-days of presentation of formal scientific papers. In addition, there was a clinical program on November 9, presented by the orthopaedic surgeons of St. Louis with Dr. J. Albert Key presiding. The meeting was well attended and the papers were excellent: the discussions were free and informal.

Metatarsus Varus in Static Feet. Dr. Elias Margo [1] and Dr. Marvin K. Margo [2] presented a large series of cases of metatarsus varus which was producing symptoms in adults. All of the patients were treated conservatively by means of supports within the shoes and wedges.

Results of Triple Arthrodesis for Rigid Flat-Foot. Dr. Robert E. Musgrave [3] and Dr. J. Leonard Goldner [4] presented their experience with the rigid or spastic flat-foot deformity and an extensive review of the literature concerning the etiology and pathology of this condition. In their opinion, triple arthrodesis was the treatment of choice in all patients who do not respond readily to non-operative measures.

[22] Montreal, Quebec, Canada.
[23] Reddy Memorial Hospital, Montreal, Quebec, Canada.
[1] 605 Northwest 10th Street, Oklahoma City, Oklahoma.
[2] 605 Northwest 10th Street, Oklahoma City, Oklahoma.
[3] Duke University Hospital, Durham, North Carolina.
[4] Duke University Hospital, Durham, North Carolina.

Single Kirschner-Wire Fixation in Triple Arthrodesis. Dr. Edward T. Haslam [5] and Dr. Jack K. Wickstrom [6] presented their experience with a series of twenty consecutive cases in which Kirschner-wire fixation of the talonavicular joint was used in conjunction with a plaster-of-Paris cast to hold the foot in position during the early phase of healing. They felt that the method could be used to advantage in obtaining proper foot positions and they had experienced no complication.

In his discussion, Dr. Clarence H. Crego, Jr.[7], declared his lack of enthusiasm for the use of any device for internal fixation in conjunction with a triple arthrodesis.

Lateral Instability of the Ankle in Paralytic Cases. Dr. Randolph L. Anderson[8], Dr. H. M. Hills, Jr.[9], and Dr. A. A. Abplanalp [10] reported on a large series of patients with poliomyelitis who had had triple arthrodesis performed. They attempted to analyze the difficulty in those in whom significant instability of the ankle joint itself developed. In some patients severe enough instability developed to warrant consideration of a tibiotalar arthrodesis.

In his discussion, Dr. Oscar L. Miller [11] stated that he had never done a fusion of the ankle joint for this particular condition.

The Management of Unstable Fractures of the Lower Third of the Tibia. Dr. William H. Ainsworth [12] reported that, in a large series of patients with unstable fractures in the vicinity of the lower half of the tibia, the use of the Eggers plate was the method of choice in securing good fixation of the fragments. It was felt that the security of the fixation, with anatomical assembling of the comminuted fragments, increased the incidence of union.

Anatomical and Pathological Considerations of Compound Fractures of the Ankle. Dr. B. F. Boylston [13] gave a very clear description of the complicating anatomical factors which make ankle fractures particularly difficult to manage and which often produce marked disabilities. Particular reference was paid to the scantiness of the subcutaneous tissues over the medial aspect of the ankle and the frequent compounding of fractures of the medial malleolus. The need for immediate anatomical restoration was stressed, as was the use of the most simple and least bulky type of internal fixation possible.

Arthrogryposis Multiplex Congenita. Dr. J. Hiram Kite [14], in his usual lucid form, presented a series of children with arthrogryposis multiplex congenita. It was his opinion that the incidence of this condition is on the increase. A review was given of the numerous ideas as to its etiology (even the field of astrology was entered). The problem of specific joint deformities was outlined.

Postoperative Infection of the Intervertebral-Disc Space. Dr. Lee T. Ford [15] and Dr. J. Albert Key [16] showed three instances of postoperative intervertebral-disc infection, two of which remained localized in the disc space. Infections were masked, no doubt, by prophylactic antibiotics, and all patients recovered after drainage of the infected space.

In his discussion, Dr. Dorsey K. Barnes [17] reported his experience with several cases. The difficulty of establishing a precise bacteriological agent was stressed.

Controversial Fractures in Children. Dr. Walter P. Blount [18], as guest speaker, gave an extremely lucid talk concerning fractures of the long bones in children. He strongly advocated conservative treatment and gave extremely interesting illustrations of the types of deformities which Nature will correct in children. Minor degrees of shortening can be readily corrected. Angulation was found to be corrected by Nature more effectively if it occurred near an epiphysis and if the apex of the angulation was in the axis of the major joint movement. It was his experience that Nature would not correct a rotation deformity or a varus or valgus deformity involving the neck of the femur.

[5] 1430 Tulane Avenue, New Orleans 12, Louisiana.
[6] 1430 Tulane Avenue, New Orleans 12, Louisiana.
[7] 634 North Grand Avenue, St. Louis 3, Missouri.
[8] 1208 Kanawha Boulevard, Charleston, West Virginia.
[9] 1208 Kanawha Boulevard, Charleston, West Virginia.
[10] 1208 Kanawha Boulevard, Charleston, West Virginia.
[11] 123 West Seventh Street, Charlotte 2, North Carolina.
[12] John Sealy Hospital, Galveston, Texas.
[13] Baylor University College of Medicine, Houston, Texas.
[14] 490 Peachtree Street, N.E., Atlanta 3, Georgia.
[15] 4952 Maryland Avenue, St. Louis 8, Missouri.
[16] 4952 Maryland Avenue, St. Louis 8, Missouri.
[17] 3701 Maple Avenue, Dallas 4, Texas.
[18] 324 East Wisconsin Avenue, Milwaukee 2, Wisconsin.

Whiplash Injuries. Dr. Eugene G. Lipow [19] discussed the very complex problem of whiplash injuries, going into great detail regarding pathological considerations of the ligaments of the cervical spine and outlined the conservative treatment which he considered to be most effective. In his experience, early treatment greatly reduced the duration of the disability and the extent of the disability, although a very considerable number of patients, under the most ideal conditions, continued to have symptoms.

Dr. Charles A. Stone [20] discussed this paper with considerable interest, since he, himself, had sustained such an injury. He felt that residual symptoms were common following the injury, regardless of whether or not the patient had any motive for prolonging his disability.

Sciatic Syndrome Due to Endometriosis of the Sciatic Nerve. Dr. Robert O. Denton [21] and Dr. John D. Sherrill [22] presented the case of an adult female with intractable sciatica. Exploration of the sciatic nerve just at and below the gluteal notch revealed involvement of the substance of the nerve with an invasive type of tissue. This proved to be endometrial on pathological and histological examination. An extensive review of the literature failed to reveal any record of a similar previous instance, although they had found numerous instances of extrapelvic endometriosis, none of which, however, involved the peripheral nerves.

Use of Hydrocortone in Spinal Surgery. Dr. Kenneth G. Jones [23] and Dr. Horace C. Barnett [24] presented a series of some 100 cases of patients with ruptured intervertebral disc in whom hydrocortone had been injected into the disc space after removal of the herniated nucleus. This series was compared with an almost equally large series of patients in whom hydrocortone had not been used. The patients in whom hydrocortone had been used had a much easier postoperative convalescence, although long-term results were not evaluated. An incidental finding in this series was that patients who had spinal anaesthesia had an easier postoperative course than those who had general anaesthesia.

The Use of Rush Nails in the Management of Colles' Fractures. Dr. W. Philip Warner, Jr.[25], expressed the opinion, based on his experience in the use of Rush nails in the management of Colles' fractures, that the use of Rush nails is a superior method of treatment for comminuted fracture of the distal extremity of the radius in adults.

Fractures of the Humeral Condyles in Adults. Dr. Robert A. Knight [26] described the mechanical considerations of fractures of the distal portion of the humerus. He advocated anatomical restoration of the fragments by means of an adequate posterior approach, secure internal fixation being used. Only with the use of this technique did he feel that the best results could be obtained.

Remarks on Orthopaedic Surgery in the South in 1954. Dr. R. Beverly Raney [27], in the Chairman's Address, gave a very interesting review of the development of the Section on Orthopaedic and Traumatic Surgery of the Southern Medical Association and outlined in general the situation of orthopaedic surgery in the South. He noted the great increase in number of orthopaedic surgeons during the past few years and the opening of new medical centers.

Comparison of Judet and Intramedullary Types of Prostheses in Non-Union of Hip Fractures. Dr. J. J. Hinchey [28] stated that, in his experience, the intramedullary type of hip prosthesis was much to be preferred in ununited fractures of the neck of the femur, as adeqate length of the femoral neck could scarcely be restored by the Judet prosthesis. There was also a marked tendency on the part of the Judet prosthesis to go into varus deformity.

Resection of the Head and Neck of the Femur for Certain Insoluble Hip Problems. Dr. Eugene M. Regen [29], Dr. Joseph A. Conroy [30], and Dr. J. William Hillman [31] reviewed the history of this radical operation and found it to have a considerable field of usefulness, particularly in treatment of ankylosis of the hip due to rheumatoid arthritis. They felt that it might be an excellent salvage procedure for failures of hip

[19] 903 16th Street, N.W., Washington, D. C.
[20] 3720 Washington Boulevard, St. Louis 8, Missouri.
[21] 1023 South 20th Street, Birmingham, Alabama.
[22] 1023 South 20th Street, Birmingham, Alabama.
[23] 1307 Donaghey Building, Little Rock, Arkansas.
[24] 1307 Donaghey Building, Little Rock, Arkansas.
[25] 4 West Hillcrest Drive, Greenville, North Carolina.
[26] 869 Madison Avenue, Memphis 3, Tennessee.
[27] University of North Carolina School of Medicine, Chapel Hill, North Carolina.
[28] 1509 Nix Professional Building, San Antonio 5, Texas.
[29] Vanderbilt University Hospital, Nashville 4, Tennessee.
[30] Vanderbilt University Hospital, Nashville 4, Tennessee.
[31] Vanderbilt University Hospital, Nashville 4, Tennessee.

prostheses. Limited functional activity of patients after this procedure does not make it advisable for use in instances in which a less radical operation might be effective.

Femoral Shortening with Intramedullary Nails. Dr. Robert M. O'Brien [32] and Dr. Richard E. Lord [33] presented their experiences with limb-shortening operations in which intramedullary nails had been used. Twelve cases were presented. In their experience with the technique the results had been extremely favorable, and they felt that it was the method of choice, in spite of the published reports of others that non-union and distraction had occurred. They felt that these complications could be readily controlled by good surgical technique and close follow-up of cases.

In discussion, Dr. G. W. N. Eggers [34] conceded the advisability of intramedullary fixation in femoral shortening, but he suggested the application of an Eggers plate, with fixation of one cortex in order to control rotation better and to prevent distraction of the fracture.

At the business meeting, Dr. George W. N. Eggers was elected Chairman of the Section. Dr. S. Benjamin Fowler was elected Vice-Chairman, and Dr. J. Leonard Goldner was elected Secretary.

HOSPITAL FOR JOINT DISEASES ALUMNI MEETING

The Alumni Association of the Hospital for Joint Diseases held its Annual Scientific Meeting at the Hospital, November 3, 4, and 5, 1954. The Chairman of the Program Committee was Dr. Harold Altman. This year the Conference was dedicated to children's orthopaedics.

The Conference was opened by the President of the Alumni, Dr. Abel Kenin; greetings followed from Mr. Abraham Rosenberg, Executive Director of the Hospital.

Wednesday, November 3, 1954
Morning Session
Chairman, Dr. George J. Ginandes, Director of the Pediatric Service

Problems in Pediatric Anaesthesia. Dr. Albert M. Betcher advised that patients be visited preoperatively in order to gain their confidence. He uses atropine or scopalamine preoperatively in the infant. Induction is by cyclopropane and nitrous oxide, the mask being held several inches from the face. Intravenous fluids are started before the drapes have been placed to avoid delay in locating veins in an emergency. The patient is not removed from the operating room until he is "through the sound barrier", nor is he left unattended in the ward before he is fully awake. Postoperative sedation is never given before that time and it is used only in minimal amounts.

Cardiac Arrest in Children. Dr. Daniel Casten and Dr. Maxwell Bardenstein reported that, of seven patients with cardiac arrest in the age group up to ten years, four had operations on the head and neck, one on the abdomen, one a closed reduction of a congenital dislocation of the hip, and one had died before the operation had begun. In six of the seven ether was the only anaesthetic agent; five of the seven were classed as being in excellent physical condition. Six patients suddenly expired after the operation had been completed and after the anaesthetic agent had been discontinued. Cardiac arrest was more common in children than in adults and the results of resuscitation were poorer. When cardiac arrest occurs, time is wasted in drug stimulation. Immediate cardiac massage is essential; no patient survived when the delay exceeded four minutes.

Neuroblastoma. Dr. Jacob Levine presented a case of neuroblastoma in which the patient had multiple osteolytic lesions. Bone-marrow biopsy had established the diagnosis. This tumor arises from the sympathetic nervous system and, next to leukaemia, is the most common cancer occurring in children. In spite of the newer forms of chemical therapy, the patient ran a progressively downhill course and expired.

Abdominal Pain of Orthopaedic Origin. Dr. Percy Klingenstein cautioned that, after severe trauma causing multiple fractures of major bones, minimal amounts of sedation should be used and that the surgeon must be ever alert to the possibility of intra-abdominal injury.

[32] 4161 Lindell Boulevard, St. Louis 8, Missouri.
[33] 4161 Lindell Boulevard, St. Louis 8, Missouri.
[34] 2201 Avenue D, Galveston, Texas.

Polyarthritis in Children. Dr. Otto Steinbrocker differentiated between an acute explosive polyarthritis, characterized clinically by a high fever and a high sedimentation rate, and a milder form of the disease, characterized by generalized malaise, anorexia, pain, and stiffness of one or several joints. The undesirable effects of prolonged cortisone therapy seen in some adults, such as psychosis, peptic ulcer, and demineralization are rarely seen in children and he felt it important, when indicated, to maintain the child on adequate doses of the drug.

Sickle-Cell Anaemia in Children. Dr. Leon Antell pointed out that the abnormality is a Mendelian dominant characteristic and is due to the hemoglobin within the cell. The defect is manifested by sickling in low oxygen tension and by a decreased average life span of the red cells to forty to sixty days (the normal is 120 days). There are various forms of hemoglobin, of which one, F (foetal) hemoglobin, will not allow sickling to occur. F hemoglobin persists for six months; this may explain the clinical observation that sickle-cell anaemia does not occur in the first half year of life. The roentgenographic findings of generalized cortical thinning, expansion of the medullary canal, and demineralization of the flat bones and vertebrae are caused by the hyperplastic bone marrow. The symptom complex of abdominal pain, arthralgia, and systolic murmur, coupled with the typical roentgenographic findings, point to the diagnosis. There is no specific therapy. Blood transfusions are used during severe crises.

Renal Rickets. Dr. Irving Claman reported a case of renal rickets, the symptoms of which were anorexia and slow development. Typical chemical findings were given. Retrograde pyelography revealed a hydronephrotic kidney on the left; the kidney on the right was not visualized. At autopsy a scarred atrophic right kidney and an infected hydronephrotic left kidney were found. Three of the four parathyroid glands were markedly enlarged. The necessity of complete diagnostic studies of children who do not develop normally was emphasized.

Dermatomyositis. Dr. George Ginandes reported his findings in cases of dermatomyositis. These included clumsiness, limitation of motion, swelling and sometimes pain in the interphalangeal joints and other joints, and a leathery consistency of the bulky muscles. Biopsy of the skin and muscles had revealed inflammatory-cell infiltration, loss of normal muscle-cell structure, and, as in other collagen diseases, fibrous degeneration of the ground substance throughout the involved regions. If the onset of the disease is fulminating, the prognosis is poor; if the onset is insidious, the prognosis is better. If the patient survives the first two years after the onset, the prognosis for life is good and for function is favorable. Administration of cortisone and physiotherapy are the treatments of choice.

Afternoon Session

The afternoon was devoted to a Clinicopathological Conference on some skeletal diseases of childhood. The session opened with words of greeting from Dr. Joseph E. Milgram, and the conference was conducted as a panel discussion. Dr. Henry L. Jaffe was moderator, and Dr. Golden Selin presented the cases. The invited panel members were Dr. John F. Caffey [1], Dr. William T. Green [2], and Dr. Samuel S. Levine [3].

The invited members of the panel knew in advance the diagnoses in the cases to be discussed, had been supplied with brief case histories, and had been informed about the relevant case material (roentgenograms, gross specimens, and microscopic specimens) to be demonstrated. The individual cases thus constituted simply points of departure for discussions of the conditions they represented.

Ten cases, of which two had come to autopsy, were presented. The conditions which they exemplified were: solitary bone cyst, central fibroma (low-grade fibrosarcoma), renal rickets (renal hyperparathyroidism), aseptic necrosis of the femoral head, localized cortical-bone abscess, tuberculosis of the bone shaft, neuroblastoma of the adrenal gland, fibrous cortical defect, osteochondritis dissecans, and Schüller-Christian disease.

In connection with almost every case, the gross pathological specimen was demonstrated by colored photographs. All of the microscopic pathological changes were likewise demonstrated with colored illustrations. Throughout the conference, an effort was made to correlate the findings in the clinical roentgenograms with those from the gross material and tissue sections. The discussion was directed mainly toward getting at what the individual case could contribute to the practical clinical understanding of the condition it represented.

Thursday, November 4, 1954

Morning Session

Moderator, Dr. H. Relton McCarroll

Chairman, Dr. Samuel Kleinberg

The subject under discussion was congenital anomalies. The following papers were presented:

[1] Department of Clinical Pediatrics, College of Physicians and Surgeons, Columbia University, New York, N. Y.
[2] The Children's Hospital, Longwood Avenue, Boston, Massachusetts.
[3] Department of Pediatrics, Cornell Medical Center, New York, N. Y.

Congenital Recurvatum of the Knee. Dr. Aaron Gold presented eight cases of benign congenital recurvatum of the knee in the new-born. All responded to conservative treatment consisting in gentle manipulations into flexion, with or without plaster-of-Paris immobilization. In contrast, one resistant case, a female, was presented. Surgery had been required; the end result was fair. Criteria were set forth, differentiating the benign from the resistant cases.

Fibrous Cortical Defect (Periosteal Desmoid). Dr. Frederick M. Marek presented two cases of benign metaphyseal cortical defects in children. These lesions are quite common and should be recognized because of their location in a metaphysis, especially in the medial femoral condyle. They are eccentric, near the cortex, and, on x-ray examination, give the appearance of a small oval or somewhat irregularly roundish area of absorption surrounded by a sclerotic border. The defect is frequently accompanied by periosteal ossification. The clinical course is asymptomatic, and most of these lesions, if left alone, eventually disappear, being replaced by normal bone. Pathologically, the lesion consists of a mature connective-tissue tumor which probably arises from the periosteum and secondarily invades the bone. The clinician can be reassured about the benign course of this condition.

Arthrography of the Hip in Congenital Dislocation. Dr. Abel Kenin reported that he had found that arthrography facilitated differentiation between subluxation and dislocation and tested the adequacy of closed reduction. If, after closed reduction, arthrography reveals interposition of the limbus, he does not delay in performing an open reduction.

In discussion, Dr. H. Relton McCarroll expressed the opinion that the stability of reduction can be easily tested at the time of closed reduction and that, possibly, arthrography is of more academic importance than of practical value.

Congenital Dislocation of the Hip. Dr. H. Relton McCarroll[4] said he feels that most dysplastic hips develop normally without the benefit of any form of therapy. However, since it is impossible to differentiate between those in which spontaneous cure will occur and those in which the acetabulum will remain deficient, he treats all dysplastic hips by means of long casts with a crossbar which maintains abduction and internal rotation. In patients with frank dislocation, he does not perform reduction for fear of traumatizing the capital femoral epiphysis. Instead, he waits until the patient is one year of age, and, at that time, using skeletal traction, he brings the head of the femur down below the level of the acetabulum. When this has been achieved, he maintains traction for an additional week. He places the head of the femur within the acetabulum by flexing the hip and by using the pressure of just one finger underneath the trochanter. The hips are maintained in the frog-leg position for two months, following which they are maintained in abduction and neutral rotation. When indicated, he performs supracondylar derotation osteotomy after he has brought the hips into abduction and neutral rotation. If a shelf operation is indicated, it is performed after the hips have been changed from the frog-leg position to a position of abduction and neutral rotation. The derotation osteotomy is performed two months after the shelf operation. In Dr. McCarroll's series, posterior dislocation was present in 60 per cent. of the patients, anterior dislocation in 23 per cent., and subluxation in 17 per cent. Clinically, posterior dislocation is characterized by prominent buttocks and an increased lumbar lordosis, whereas anterior dislocation is characterized by flat buttocks, a flat lumbar spine, and the protrusion of the femur into the femoral triangle. In anterior dislocation the prognosis is poor; in 80 per cent. of the patients, redislocation occurred. The construction of a massive anterior shelf to prevent redislocation is a difficult mechanical procedure because of the thinness of the iliac bone in this region. Not only is the redislocation common but also secondary changes in the femoral head caused by pressure against an incongruous surface occur. When symptomatic dislocation persists in early adult life, Dr. McCarroll suggested arthrodesis if the dislocation is unilateral; if it is bilateral, he suggested subtrochanteric osteotomy. Arthroplasty or the insertion of a prosthesis is reserved for patients in the older age groups with severe symptoms.

Experience with Congenital Hip Lesions of Infancy. Dr. J. E. Milgram and Dr. Charles M. Hanisch had collected since 1932, through instructed groups of obstetricians and pediatricians, a considerable clinical series of congenital lesions of the hip. They had found that the problem of treatment in the first year of life is usually not a problem of attaining reduction alone, but one of maintaining normal viability of the replaced ossifying cartilage of the capital femoral epiphysis. A wide variety of epiphyseal injuries was presented and was analyzed in relation to methods of reduction. No sudden reduction is safe, even when performed with ease and without anaesthesia; nor has any method as yet proved to be completely atraumatic. Even "simple abduction" may occasionally damage the epiphyses not only of the abnormal, but of the normal, hip. Yet, abduction, gently increased, is reasonably safe in patients in the youngest age group, providing hip extension is not forced concomitantly and providing the knees are not fixed in extension, as in the Denis Browne splint or in extended knee-length casts. In the early weeks of life, the infant is still a quadruped. A foam-rubber

[4] 3720 Washington Boulevard, St. Louis 8, Missouri.

diaper, which they demonstrated, was the simplest and commonest appliance they had used for infants. Reduction by traction, performed in the position of hip flexion in the hip seen early and in a position of extension in the hip seen late, has been particularly satisfactory in difficult cases. Pelvifemoral braces of various types are of value in the after-care to permit active hip motion in the position of abduction.

They emphasized that weight-bearing should be delayed, if necessary for years, until the capital femoral epiphysis is unquestionably normal or has attained maximum viability. They demonstrated damage resulting from too early weight-bearing.

Afternoon Session
Chairman, Dr. Joseph Stone

Surgical Treatment of Spastic Deformities of Lower Extremities. Dr. Caroll Silver and Dr. Stanley D. Simon showed a motion picture on the surgical treatment of spastic deformities of the lower extremities. They prefer to operate, when indicated, at an early age before contractures and habitual poor gait become fixed. In their experience, three years is the optimum age. They showed films of severely handicapped children, unable to walk without being supported, who had undergone intensive non-surgical rehabilitation without material benefit and who, several months after surgery, walked without external support. With the use of two teams, they performed, at one sitting, extensive adductor myotomy with anterior and posterior obturator neurectomy, as well as gastrocnemius-head recession below the joint line, with tibial neurectomy to the gastrocnemius muscle.

Reconstruction Surgery in an Advanced Case of Still's Disease with Multiple Ankylosis and Deformities. Dr. Michael Scala and Dr. Caroll Silver demonstrated that, in the face of seemingly hopeless ankylosis of multiple major joints in Still's disease, much can be done to improve the patient's functional capacity and to lessen the burden of care. Their patient, a girl, twenty-two years old, rigid in extension at all major joints, following arthroplasties of the elbows and the hips, now feeds herself, performs the necessary hygienic tasks, and has become a commercial artist.

Bilateral Slipped Epiphysis with Fracture of the Shaft of the Femur. Dr. Benjamin Greenberg described two cases of bilateral slipped epiphysis with fracture of the shaft of the femur; both occurred three months postoperatively, and the site of fracture was at the point of the insertion of intramedullary fixation. In one patient a Smith-Petersen triflanged nail had been used; in the other, three threaded wires had been used. Both lesions healed uneventfully following conventional treatment of the fracture.

Aseptic Necrosis of the Proximal End of the Femur following Osteomyelitis. Dr. Eliot Friedman reported the case of a twelve-year-old female with aseptic necrosis of the femoral head which had occurred one year after apparently complete recovery from a focus of infection in the intertrochanteric region. This had been treated conservatively with antibiotics. A second case had occurred in a six-year-old boy following a focus in the neck of the femur which had also been treated and apparently cured with antibiotics.

In the discussion which followed, Dr. Joseph Buchman advised early drilling and decompression of the proximal end of the femur, if there were any local signs, even though the general condition of the patient was markedly improved.

Dr. H. Relton McCarroll dissented, stating his belief that the occurrence of aseptic necrosis would be made more probable by surgery. If the general condition of the patient is improving, his policy is to continue conservative treatment. He believed that the infection is in cancellous bone and the blood stream would carry antibiotics to the focus of infection.

Tuberculosis of Bone and Joint. Dr. Leon Sheplan related his experience with a considerable number of cases of tuberculosis of the bones and joints in Puerto Rico. The incidence and severity of tuberculosis was rapidly diminishing, primarily because of the liberal use of isoniazid which he found relatively non-toxic.

Dr. Joseph Buchman, in discussing this condition, emphasized that present-day surgical treatment has as its goal the preservation of joint function. With the patient under treatment with isoniazid, he excises as much of the tuberculous foci as possible and performs primary wound closure. With this regimen favorable early results with apparent elimination of the disease and preservation of joint function have been obtained.

Adolescent Round-Back Deformity — A Late Result of Poliomyelitis. Dr. Victor Raisman enumerated the conflicting theories concerning the etiology of round-back deformity and suggested that subclinical poliomyelitis was the cause.

Roentgenograms in Congenital Anaemias. Dr. Maurice Pomeranz pointed out that, in the skull, the inner cortex is normal, the marrow cavity appears to be expanded, and the outer cortex is thin or is not visi-

ble. He demonstrated that sickle-cell anaemia and Cooley's anaemia are roentgenographically identical and that the differentiation must be established clinically.

FRIDAY, NOVEMBER 5, 1954
Morning Session
Moderator, Dr. George J. Garceau
Chairman, Dr. A. F. Serbin

Paralytic Supination Contractures in the Forearm. DR. MICHAEL BURMAN said that, of the various methods of overcoming paralytic supination contractures in the forearm, such as osteotomy of the humerus, osteoclasis of both forearm bones, and osteotomy of the radius, he prefers osteotomy of the radius. He intentionally seeks non-union in order that a newly paired joint system may be developed.

Dr. Garceau emphasized that it is first necessary to derotate the humerus in order that an accurate estimation of the degree of supination contracture can be made.

Erb's Palsy. DR. CHARLES SUTRO and DR. PETER KENMORE questioned the historical concept that Erb's palsy is solely in the nerve roots because of the usual normal sensory findings even in extensive palsy.

Subtalar Joint, Its Anatomy and Lesions. DR. PAUL LAPIDUS demonstrated, with the aid of anatomical preparations and models, the axis of the subtalar joint and showed that it comprises a posterior unit between the talus and the calcaneus, a medial unit between the talus and the sustentaculum tali, a lateral unit between the talus and the calcaneus, an anteromedial unit between the talus and the navicular, and an anterolateral unit between the calcaneus and the cuboid. All units are functionally dependent. The strength of the subtalar joint is due not only to the strong interosseous ligaments but also to the double reversed ball-and-socket arrangement between the talus and the calcaneus. Posteriorly, the ball is the calcaneus and the socket is the talus; anteriorly, the ball is the talus, and the socket is composed of the calcaneus, the navicular, and the spring ligament.

A Few Notes on the Congenital Pes Adductus. DR. OTTO FLIEGEL attempted to clarify the nomenclature of congenital foot deformities. If the fore part of the foot is adducted, even though there is an accompanying varus deformity, and if there is no shift of the tarsal bones in relation to the metatarsus, he terms the condition "pes adductus". If the tarsus is shifted with accompanying involvement of the metatarsus, he prefers the term "metatarsus varus". In the latter condition the treatment and prognosis differ from those of simple pes adductus.

Operative Treatment of the Paralytic Foot. DR. LEO MAYER related his experiences with tendon transplantations. He had first performed tendon transplantations by the so-called "physiological method" without arthrodesis. While overcorrection had never occurred in paralytic club-foot, there were a significant number of cases of paralytic flat-foot in which overcorrection did occur. He had, therefore, changed his technique and had waited for the patient to reach puberty, at which time he performed simultaneous tendon transplantation and Hoke arthrodesis. At the present time, in young children with progressive deformity, he performs tendon transplantation without bone stabilization, using a Bunnell pull-out wire to anchor the tendon to its new insertion.

Resistant Club-Foot. DR. GEORGE J. GARCEAU[5] stressed the importance of a single surgeon supervising the treatment, with frequent revisits after correction has been obtained, in order that the earliest signs of relapse may be noted. Following correction, he pursues an insistent regimen of night splints, daily manipulations by the mother, and the wearing of corrective shoes. He listed as the causes of relapse, underdevelopment or complete absence of muscles, anomalous insertion of tendons, tibial torsion, and primary neuromuscular diseases. In those patients in whom the navicular cannot be adequately aligned, he severs the tibialis posterior and uses further wedged plaster casts. He makes no effort to reattach the tendon. If the foot persistently supinates in the relaxed position, he transfers the tibialis anterior to the base of the fifth metatarsal and continues the use of a wedged plaster cast. If, at the age of four, tibial torsion persists, he recommends tibial osteotomy. If, at the age of ten, there is still deformity, he advocates triple arthrodesis. In severe adductocavus feet, he has performed neurectomies of both medial and lateral plantar nerves with gratifying results.

Afternoon Session
Chairman, Dr. Isadore Zadek

The Role of the Spinal Cord in the Induction and Structuring of the Vertebral Column. DR. SAMUEL R.

[5] Hume-Mansur Building, Indianapolis 4, Indiana.

DETWILER [6] described research carried out in his laboratory in collaboration with DR. HOWARD HOLTZER [7]. Using small amphibian embryos, he had implanted segments of the spinal cord into the lateral portion of the mesodermic somites; this resulted in the development of cartilaginous vertebral arches around the grafted spinal cord. The induced vertebral column became segmented in normal fashion. The phenomenon occurred in the absence of the notochord. In other experiments in which the notochord had been excised, a heavy bar of cartilage formed in its place, and normal vertebral arches developed. In experiments in which the spinal cord had been split longitudinally for several segments and in which mesodermal tissue had been implanted between the split halves, the formation of cartilaginous arches around each half of the split cord resulted. In embryos in which a section of spinal cord had been removed, no vertebrae developed. These various results supported the conclusion that the formation and the molding of the vertebral column are dependent upon the presence of the spinal cord.

When mouse somites were implanted radially around a piece of spinal cord in tissue-culture media, they gave rise to cartilage masses. If no spinal cord had been present in such tissue-culture preparations, no cartilage differentiation occurred. If only the dorsal half of the spinal cord had been used, there was no cartilage differentiation; but, if the ventral half of the cord was present, cartilage bars appeared. Linear arrangement of mouse somites, adjacent to a piece of spinal cord *in vitro*, resulted in the formation of cartilaginous bodies first nearest to the cord and then progressively more distant.

Discussion brought out the observation that these studies promise new avenues of investigation of scoliosis and congenital deformities.

Anatomical Pitfalls in the Treatment of Torticollis. DR. EMANUEL B. KAPLAN described variations of muscles and additional muscles inserted into the clavicle which may contribute to the persistence of torticollis after the accepted division of the sternocleidomastoid muscle. Rare congenital disturbances of the occipito-atloid junction and important venous anastamoses were described. These can be responsible for errors in diagnosis and also may cause difficulties in the operations for correction of torticollis.

Resistant Non-Union of the Humerus. DR. THOMAS HOROWITZ presented two cases of resistant non-union of the humerus in each of which, despite three expertly performed bone-grafting procedures, non-union had resulted. He had bridged the gap with an intramedullary prosthesis and in both cases stability and excellent range of motion in adjacent joints developed. The intramedullary prosthesis was well tolerated.

Fractures of the Spine. DR. OTTO LEHMAN discussed eight cases of fracture of the spine, two of which occurred in patients with osteogenesis imperfecta and the remaining six of which occurred in normal children. He emphasized the frequency with which multiple vertebral compressions can be overlooked. In all patients, following minor or severe trauma, the pain was mild, the physical examination disclosed minimal signs, and the roentgenograms revealed either severely compressed vertebrae or multiple fractures. Lateral laminagrams were more useful than lateral roentgenograms. In patients in whom a lumbar vertebra had been severely compressed, closed reduction, a plaster-of-Paris body jacket worn for three months, and an extension brace for sometime thereafter, produced excellent and lasting restoration of contour.

Supracondylar Fractures of the Humerus. DR. JULIUS NEVIASER and DR. SANFORD EISENBERG condemned open reduction; they opposed traction as being financially and physically burdensome; and they stated their preference for manipulation under anaesthesia followed by the use of a posterior splint maintaining the elbow at 90 degrees.

In the ensuing discussion, DR. GEORGE J. GARCEAU related that he had encountered associated vascular accidents in supracondylar fractures.

Fracture of External Humeral Condyle in Childhood. DR. HENRY MILCH demonstrated anatomically that, if the fracture line passed through the capitellum, no lateral dislocation of the elbow resulted; but, if the fracture line occurred more medially through the trochlear ridge, the joint was unstable and lateral dislocation resulted. The joint could be rendered stable if it was placed in complete extension so that the olecranon was firmly wedged into the olecranon fossa. He recommended that, in this type of condylar fracture, an exception to the general rule was necessary, the elbow after manipulation must be maintained in complete extension.

DR. GEORGE J. GARCEAU, in discussing the paper, advised open reduction in all fractures of the external condyle as being the only method of ensuring anatomical alignment.

[6] Department of Anatomy, College of Physicians and Surgeons, Columbia University, New York, N. Y.
[7] Department of Anatomy, College of Physicians and Surgeons, Columbia University, New York, N. Y.

SOCIEDAD ARGENTINA DE ORTOPEDIA Y TRAUMATOLOGIA

Under the aegis of the Argentine Society of Orthopaedics and Traumatology, a meeting was held in the Province of Cuyo, December 2 to 5, 1954.

The meeting was held in two cities, Mendoza and San Juan. Specialists from all over the country attended this meeting. There were present a few representatives from Chile, Paraguay, and Colombia. Three subjects were discussed.

In the City of Mendoza

The paralytic hand was discussed. It was demonstrated that surgery of the hand has improved during the last few years because of the application of a combination of the principles of orthopaedic surgery, plastic surgery, and neurosurgery.

Dystrophic and metabolic osteopathies were shown. Orthopaedic surgeons, endocrinologists, and pathologists presented different aspects of several diseases in thirty short communications. Some cases in which diagnosis was difficult were shown. The conclusion reached as the result of these presentations was that at times the diagnosis can only be made after pathological study.

In the City of San Juan

The treatment of fractures of the ankle was discussed. Indications for conservative treatment, skeletal traction, osteosynthesis, and primary arthrodesis were presented. The correct treatment of compound fractures was emphasized and the treatment of severe sequelae was demonstrated.

DR. LEO MAYER RETIRES FROM THE JOURNAL BOARD

Dr. Leo Mayer recently retired from the Board of Associate Editors of *The Journal*. Twenty-five years ago he was appointed to the Advisory Editorial Staff by Dr. E. G. Brackett, and since then he has served *The Journal* continuously. With rare scholarship, wisdom, justice, and courage — far beyond the knowledge of all but a very few closest to *The Journal* — he has contributed immeasurably to the Journal's development. His retirement came through the recently established policy of rotation of Associate Editors, based on a three-year tenure of office. Through this provision, others may participate in the work of *The Journal* as part of their contribution to surgery. The Editor and the Board of Associate Editors wish to pay tribute to him, trusting that they may long have the benefit of his wise counsel.

At the Annual Meeting of the Board of Associate Editors, held at Los Angeles on January 29, the Editor presented to Dr. Mayer a traveling clock, suitably engraved, and an engrossed parchment with the following tribute signed by past and present members of the Board of Associate Editors:

> We, the members of The Board of Associate Editors, past and present, of *The Journal of Bone and Joint Surgery* wish to express the deep regret we feel as by rote you give up your active service with The Journal, first as a member of the Advisory Editorial Staff (1930–1935) and since as a member of The Board of Associate Editors (1935–1955).
>
> Throughout these twenty-five years you have been untiring in your devotion to your editorial duties, learned, wise, and just to a surpassing degree. As a result you have contributed in large measure to the growth, merit, and value of The Journal and to the advancement of Orthopaedic Surgery.
>
> We will always remember the satisfaction we have had in being privileged to work with you.
>
> Our esteem and affection go with you as your term of service closes and we hope The Journal will continue to have a place in your heart and be privileged to enjoy your advice which a long and rich experience has made invaluable.

FREMONT A. CHANDLER, M.D.

1893–1954

Progress is made by the vision and action of those of us who put duty before self, whose everyday lives are filled with thoughts and deeds leading to the advancement of their chosen work. This was one of our great leaders who has left us, left his many friends here and abroad with memories of having known a great and good physician, and left our specialty with outstanding contributions by which he will long be remembered. The active and productive life of Fremont A. Chandler came to an end suddenly and without warning on Christmas Eve 1954.

Mont was born in Chicago on November 29, 1893, the son of Dr. Fremont E. and Mary S. Chandler. He attended elementary and high school in that city and, when it came time to decide about college, it was his father's wish that he enter the School of Agriculture at the University of Wisconsin. This he did. One of the outstanding things which Mont learned in this School of Agriculture was that, in the judging of stock, the pedigree of the animal should be studied and the animal should be observed in structural appearance, performance, and behavior. This he never forgot and, in teaching orthopaedic surgery, he insisted that, before a diagnosis was made, the patient's family history should be carefully reviewed and the patient should be studied as an entity, with the examination never being limited to a local part, but always including the whole body. By his junior year in college, Mont had convinced his father that medicine was his chosen profession and so he transferred to this branch, receiving his B.S. in Medicine from the University of Wisconsin in 1916. The next year he spent coaching football and basketball in order to have sufficient funds to complete his medical course at Columbia University (College of Physicians and Surgeons) from which he was graduated in 1919. He served as Resident at the Sloane Maternity Hospital in New York City and took his internship at the Hartford Hospital at Hartford, Connecticut, in 1919–1920.

It was at this point that he was uncertain of his specialty and so he accepted a position as Resident Surgeon in the Grenfell Hospital, St. Anthony, Newfoundland, 1920–1921. During that year he covered much of that rugged country, traveling by dog team in winter and by small boats in summer. There was a great amount of bone tuberculosis in northern Newfoundland and this had a great deal to do with his decision to turn from obstetrics, the specialty which he had considered, to orthopaedic surgery. After his return to the United States, he took his orthopaedic residency at the New York Orthopaedic Dispensary and Hospital, 1921–1924. During the summer of 1921, he met a nurse's aide, Eleanor Cromwell of New York, who, on February 9, 1924, became his devoted wife. Two sons were born, Stuart and Stephen Cromwell Chandler (the latter is now Lieutenant, junior grade, United States Navy Reserve).

In 1924, Mont began the practice of orthopaedic surgery in Chicago. Throughout his years of practice in Chicago, he was on the Staff of St. Luke's Hospital, where he became a senior Attending Orthopaedic Surgeon. In 1924, he was appointed an instructor on the Faculty of Northwestern University School of Medicine, and he was advanced through the succeeding fifteen years to the rank of Associate Professor. In 1943, he resigned from Northwestern to go to the University of Illinois School of Medicine as Professor of Orthopaedic Surgery and head of the department in the Medical School and in the Research and Educational Hospitals. He was on the Staff of the Children's Memorial Hospital from 1925 to 1943, being the Chief of the Orthopaedic Department from 1931 to 1943. In addition, he was a consultant at different times to six other Chicago hospitals.

Some of his other appointments and memberships were as follows:

Medical Societies:

The American Orthopaedic Association (President in 1952),
The American Academy of Orthopaedic Surgeons (Treasurer, 1944–1949),
International Society of Orthopaedic Surgery and Traumatology,
Chicago Orthopaedic Society (Past President),
The Clinical Orthopaedic Society (President, 1940–1941),
The Orthopaedic Research Society (President-Elect, 1954),
The Orthopaedic Research Foundation (Member of Joint Committee on Organization, 1954),
American Medical Association (Secretary of the Section on Orthopaedic Surgery, 1932–1935; Vice-Chairman, 1935–1936; Chairman, 1936–1937),
American Academy for Cerebral Palsy,
American College of Surgeons,
International College of Surgeons (Honorary Member and Vice-President, 1954),
American Rheumatism Association (Charter Member),
The Central Surgical Association,

FREMONT A. CHANDLER

Illinois State Medical Society,
Chicago Medical Society,
Society of Medical History of Chicago,
The Institute of Medicine of Chicago,
Advisory Board of Medical Specialties,
Alpha Omega Alpha Honorary Medical Fraternity,
Sigma Xi Honorary Fraternity,
Phi Beta Pi Medical Fraternity.

Editorships:

Associate Editor of Lewis Walter's *Practice of Surgery*, 1941–1954,
Associate Editor of *Geriatrics*, 1953–1954,
Associate Editor of *The Journal of Bone and Joint Surgery*, 1948–1954.

Military Appointments:

United States Army Medical Corps, 1917–1918,
Civilian Consultant to the Surgeon-General of the Army, 1943,
United States Navy Reserve Medical Corps, 1928–1938 (Lieutenant senior grade).

The greatest honor of Mont's life came in 1950, when he was made President-Elect of The American Orthopaedic Association. He served as the presiding officer for The American Orthopaedic Association for the noted London Meeting of the six English-speaking Orthopaedic Associations of the world in 1952. This he did with great dignity and in a manner which made all of his fellow Americans justly proud of their President. He received from Queen Mother Elizabeth the Jewel of Office which The British Orthopaedic Association presented to the president of each English-speaking orthopaedic association. At the banquet, along with the words of the toastmaster, Sir Harry Platt, and the speeches of Sir Reginald Watson-Jones, Rt. Hon. Iain Macleod (the Minister of Health), the Marquess of Reading, and the Rt. Hon. Lord Justice Birkett, Dr. Chandler's toast, "Orthopaedic Surgery", will long be remembered for its clarity, forcefulness, and appropriateness.

Mont's greatest contribution to orthopaedic surgery was undoubtedly the work he did in association with Dr. Henderson, Dr. Ryerson, Dr. Campbell, and others in the organization and setting up of The American Board of Orthopaedic Surgery. The establishment of our Board in 1934 represented, undoubtedly, one of the great milestones in our history, and he had a major part in it. He was the first Secretary of the Board and remained in this office until 1941 when he became President. During his many years of service on the Board he continually fought for better orthopaedic education and for the raising of the standards of orthopaedic training. He fully realized that Board certification sometimes was given undue importance, and that performance, character, and the qualities of leadership were far more important to an orthopaedic surgeon than a Board certificate. In the words of the present Board secretary, "He made the Board what it was". For this contribution, all of orthopaedic surgery should be forever grateful.

Mont was an individual who had the respect of all. He was a fighter for truth, justice, and right. In discussions his words were few, well chosen, and always meaningful. He was unable to be superficial in words and actions. He was admired by those who knew him for his sincerity, conscientiousness, frankness, and integrity. He was one whom some have called a decisive personality; his opinions were definite, but never unalterable if he were convinced that he was not in the right. He was noted for his promptness. His personality was stimulating to residents, associates, and friends; he had the knack of having his younger assistants do the things they should do without being asked. He was satisfied only with perfection in everything he did, and he demanded the same of those who worked for him. He could not tolerate an inferior quality of work or second best from an assistant. He was never boastful of what he did. He had a tremendous capacity for work and expected his assistants to maintain the pace he set. He was always willing to do more if it was related to his beloved orthopaedics.

Under a sometimes stern-appearing exterior, Mont was extremely kind and warm-hearted, with a good sense of humor. He was mindful of the thoughts and feelings of others. He took misfortune when it came without complaint, always in a quiet and dignified manner. He had what has been described as fundamental dignity, extreme graciousness, and gentlemanliness.

Mont was a good administrator and loved to teach. It has been said that he was a born teacher and was always teaching. He was keenly interested in all medical research. He had a definitely creative mind and always wanted time to do more research of his own. He became particularly interested, in the last few years of his life, in undergraduate teaching and especially in the development of simple teaching aids. He was responsible for the publication of *The Manual of Orthopaedic Surgery*, which was prepared under his direction and sponsored by The American Orthopaedic Association in cooperation with the Undergraduate Teaching Committee of The American Academy of Orthopaedic Surgeons. It was originally financed by the John R. Thompson Fund, which was established by one of his patients. *The Manual* is now used by nearly every orthopaedic teaching service in the United States and is to be translated into other languages. He loved the training of his residents. He was never too busy to stop and show a new resident something he thought he should know. In his teaching of younger men, a favorite expression was, "Anybody can do the major things in medicine, but it takes a good doctor to do the last 5 per cent. of the details". How true this statement is!

As an orthopaedic operator, he was superb and had few peers at the operating table. There was no lost motion; he was deliberate, fast, resourceful, accomplished, and skillful with his instruments, especially with a curette. He loved mechanical things which were efficient and he had the ingenuity to invent and to perfect many instruments of his own creation. He was particularly good in all spine work, especially in fusing a low back and in approaching an intervertebral disc. His hip fusions and foot stabilizations were outstanding. His operative judgment was always considered excellent, but with a difficult case he would invariably weigh the opinions of his associates before coming to a decision.

His writings through his thirty years of practice were many and always good. What he said and wrote was thoroughly prepared and substantiated by facts and sound experience. Twenty-six of his more than seventy publications were on problems of the crippled child, with seven of these relating to cerebral palsy. He was devoted to children and especially to his work with the child with cerebral palsy. His patellar advancement operation in the flexed knee of the spastic child is well known. Nine of his publications were on problems of the low back. Some of these are classic. He will long be remembered for his operation of trisacral fusion for low-back pain, the description of which in 1929 was his first paper. His work on spondylolisthesis

was among his best. He had three particularly good papers on torticollis, for which work he was widely known. His 1951 Academy exhibit, with two associates, on "The Recording Oscillometer in Orthopaedic Surgery" followed by a publication, was one of his very satisfactory contributions; for this he was given an Academy Gold Medal Award. His chapters in Brennemann's *Practice of Pediatrics* and Christopher's *Surgery* were among his best writings.

Mont's hobbies were few. His first interest was his work, and this can be easily believed by those who knew him well, for he was dedicated to orthopaedics and research. Some say he did not "get the fun out of life" he should; his fun was found in his family and his work. Nothing took precedence over orthopaedics; but when he played, he played hard. He loved and knew photography and took beautiful pictures. He liked to work in a shop—he had a small one in his home. His vacations were usually spent in travel or on a ranch in Montana with horseback riding, fishing, and rifle target practice. He liked to browse in hardware stores where he got ideas for instruments. He often gave his residents good English pocket knives and special saws for cutting casts. He helped to develop an oscillating electric saw in the early 1930's, but he did not have it put in production, because he felt it was never mechanically right and was too complicated for general use. This was the forerunner of our present motor saws.

Throughout his professional career no one gave him greater and finer support than his devoted wife. He looked up to her, always admired her, and greatly relied upon her judgment in many matters other than home and family. She was his constant companion, working with him on problems with which she could be of assistance, helping him in the preparation of many papers, and comforting him in times of undue stress and strain.

He closed his Presidential Address to The American Orthopaedic Association by saying,

> "As I leave the office in which I have felt it such an honor to serve, my most sincere wish for all of you is that you may be receptive of the tribute paid to doctors by Jeshua, the son of Sirach, early in the second century before Christ. He writes:
>
> '. . . The skill of the physician exalts him,
> And he is admired among the great.'"

Truly, Fremont A. Chandler is a worthy example of Jeshua's saying. He was "admired among the great" of his day, and long will he be remembered in the days to come for the sound and lasting contributions he made to his beloved orthopaedic surgery; and with the passage of time, his name will grow.

A. R. Shands, Jr.

HENRY PAGE MAUCK

1891–1955

Henry Page Mauck died quite suddenly on January 22, 1955, in Richmond, where he had grown up, gone to school and to the Medical College of Virginia, and spent the greater part of his life. He was not only deeply beloved there, but his influence had also spread far beyond that intimate circle. It is as a top-flight orthopaedic surgeon, careful investigator, and thoughtful writer, a teacher of students and young surgeons, a sound thinker and wise counselor, and a man of gentleness and personal magnetism that Page Mauck will be missed by his confreres and friends.

He was born in Richmond in 1891 and was graduated in medicine in 1913, having not only won his M.D. at twenty-two, but also having clerked evenings at a nearby drug store to help pay his way. He served his internship at the Johnston-Willis Hospital in Richmond and from there went to the Johns Hopkins Hospital for two years, becoming the second full resident surgeon on the newly established Orthopaedic Service under Dr. William S. Baer. He thus was a pioneer in an entirely new phase of surgical training in the specialties, developing at that time in teaching institutions.

He returned to Richmond and was for a time associated with Dr. William T. Graham. In 1917 he volunteered for military service as a First Lieutenant and member of Richmond's "McGuire Unit". Later he was transferred to the Surgeon-General's Office, was promoted to Captain, and was placed in charge of Orthopaedic Surgery in the camps of the Southeastern States. Finally he served for ten months at Walter Reed General Hospital until the War's end.

On his return to Richmond in 1919 he resumed independent practice, but spent much time and energy

HENRY PAGE MAUCK

directing and teaching orthopaedics at his Alma Mater, the Medical College of Virginia, where he ultimately became full Professor of Orthopaedic Surgery in 1945. He was an active force in the organization and building of the Crippled Children's Hospital in Richmond, a charter member of its Professional Staff when it opened in 1928, and its Chief Surgeon at the time of his death. With his associate, Dr. R. D. Butterworth, he organized the Tidewater Orthopaedic Clinic, a mobile unit bringing regular free orthopaedic care to the crippled children of that section of Virginia.

As he served his patients, his city, and his beloved Tidewater Counties, so he gave himself as unselfishly to larger demands as a member of many medical organizations, civic, state, and national. He was a Fellow of the Southern Surgical Association and of the American College of Surgeons, a charter member of The American Academy of Orthopaedic Surgeons, and a member and officer of The American Orthopaedic Association. As Treasurer of the latter, he was for many years a member of The Journal Committee, and he did much constructive work, first in building up its finances and finally in consummating its recent incorporation.

This brief résumé of his major activities, however, fails to give a complete picture of the man. His patients looked up to him, his confreres and associates admired and respected him, his students were stimulated and inspired by him, his friends, a legion, devoted to him, his cronies, especially those of the Robert Jones Club, loved him, for the closer one came to Page Mauck, the more one found to win the best response one

could give. It is indeed fortunate that he has left three fine sons to be a comfort to his widow and to carry on the high medical traditions (two are doctors and one is a third-year medical student) which he so modestly but faithfully embodied.

Robert W. Johnson, Jr.

CHARLES MAYOR JACOBS

1872–1954

Dr. Charles Mayor Jacobs, one of the first orthopaedic surgeons to practice this specialty in the Middle West and a man who, throughout his long and useful life, was loved by his patients and admired and respected by his orthopaedic colleagues, died in his home in Winnetka, Illinois, on September 11, 1954.

Charles Jacobs was born in St. Louis, Missouri, May 23, 1872, the son of Adolph and Fanny (Goldsoll) Jacobs. Adolph Jacobs came to this country from Germany and settled in St. Louis, later moving to Denison, Texas, where he was a merchant. Charles Jacobs attended the public schools of Denison, Texas, and in 1894 was graduated from Northwestern University Medical School. The medical diploma of Dr. Jacobs bears the names of many world-renowned physicians, including Billings, Andrews, Finger, Haggard, Zeisler, Plummer, and Ridlon, who were his professors in Medical School.

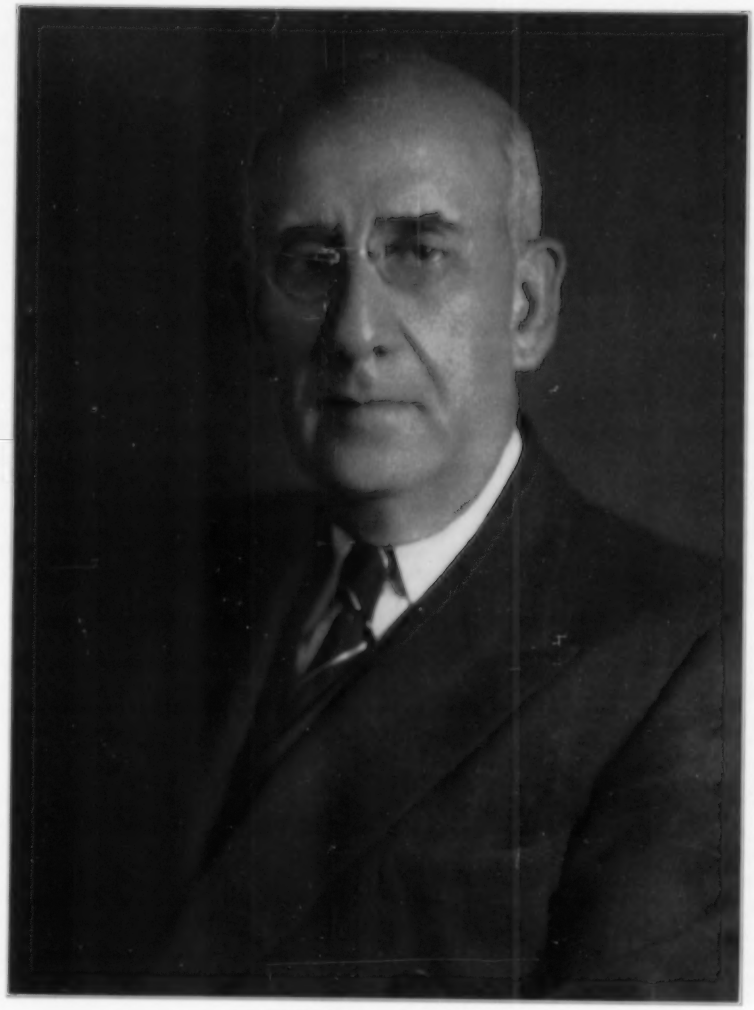
Dr. John Ridlon, the first orthopaedic surgeon in Chicago, was chief of an orthopaedic clinic for crippled children, and in 1894 he requested Dr. John Lincoln Porter, Dr. Edwin Ryerson, and his most recent student, Dr. Charles M. Jacobs, to work with him in that clinic as his assistants. The three assistants became instructors in the Medical School of Northwestern University, and all three assisted Dr. Ridlon in his private practice. The hospital and clinic of which Dr. Ridlon was Chief and in which Dr. Jacobs served for many years was known as the Home for Destitute Crippled Children and was located on the corner of Paulina and Maypole Streets. This was the only hospital and clinic in the city of Chicago at that time where a young physician could learn the techniques and principles of orthopaedic surgery. Many orthopaedic surgeons received their training under the supervision and direction of Dr. Ridlon, Dr. Porter, Dr. Ryerson, and Dr. Jacobs. Dr. Jacobs studied in Berlin for sixteen months and spent a shorter period in Vienna where he worked with Dr. Lorenz Böhler. Dr. Jacobs also worked at the Emanuel Mandel Clinic on Maxwell Street, where the least privileged citizens of Chicago came for medical care. After completing his term as Senior Orthopaedic Surgeon at Michael Reese Hospital, he organized the Orthopaedic Department of Mount Sinai Hospital. Several orthopaedic surgeons received their training there as residents, assistants, and associates.

One of the problems which constantly faced the orthopaedic surgeon of the early 1900's was that of bone and joint tuberculosis. Many orthopaedic wards were filled with patients with draining sinuses from destructive tuberculous lesions of the spine, hip, knee, or other joints. Dr. Jacobs contributed a chapter on "Tuberculous Disease of Bones and Joints" to *Pediatrics* edited by Dr. Isaac A. Abt, head of the Department of Pediatrics at the Sarah Morris Hospital, the children's unit of Michael Reese Hospital. Dr. Abt was instrumental in persuading Dr. Jacobs to organize and conduct an orthopaedic clinic at Sarah Morris Hospital. In 1924, W. B. Saunders Company published a book edited by Dr. Jacobs, entitled *Bone and Joint Tuberculosis*. Dr. Jacobs also wrote and published a number of papers about bone and joint tuberculosis and was one of the first to propose the use of autogenous bone grafts in the treatment of fractures and for fusion of tuberculous spines. Other subjects about which he talked and wrote were: congenital torticollis, luxation of the atlas and axis, compression paralysis in Pott's disease in adults, and spontaneous dislocation as a sequel.

From 1908 to 1919, Dr. Jacobs was Assistant Professor of Orthopaedic Surgery at the University of Illinois Medical School. In addition to serving at the Sarah Morris Hospital, the Michael Reese Hospital, and, later, at Mount Sinai Hospital, he served as a member of the Clinic and Examining Board of Cook County Hospital.

During the period of the First World War, Dr. Jacobs was a member of the Medical Advisory Board to the United States War Department. He was a Fellow of the American College of Surgeons, a member of The American Orthopaedic Association, The American Academy of Orthopaedic Surgeons, the Clinical Orthopaedic Society, the Chicago Medical Society, the Illinois State Medical Society, the American Medical Association, and was certified by The American Board of Orthopaedic Surgery.

Dr. Jacobs was married in Richmond, Virginia, October 27, 1902, to Helene, the daughter of Isaac Thalhimer, a merchant of that city. Charles and Helene Jacobs had two children, Charles Richmond and Amelia.



CHARLES MAYOR JACOBS

The eighty-two years of the life of Charles Jacobs spanned a period which saw the birth of orthopaedic surgery in the Middle West and included the growth and development of this young specialty to its present prominent position in medicine and surgery. In this dramatic growth and development of orthopaedic surgery in the Middle West, Charles Jacobs played a significant part.

Edward L. Compere

News Notes

THE AMERICAN ORTHOPAEDIC ASSOCIATION

The Sixty-eighth Annual Meeting of The American Orthopaedic Association will be held at The Greenbrier, White Sulphur Springs, West Virginia, June 19 to 22, 1955, under the presidency of Dr. J. Warren White. The tentative program of the Meeting as submitted by the Program Committee is as follows:

SUNDAY, JUNE 19

Morning Session

9:00 A.M.

Functional Bracing for the Upper Extremity.
Edwin R. Schottstaedt, M.D., San Francisco, California.
George Robinson, San Francisco, California (by invitation).

Upper-Extremity Prostheses for Juvenile Amputees.
Claude N. Lambert, M.D., Chicago, Illinois.

Report of Exchange Fellowship Activities in England.

The Water Content of Bone and Its Relationship to the Organic and Mineral Components of Bone Matrix.
Robert A. Robinson, M.D., Baltimore, Maryland.
Stuart R. Elliott, A.B., Baltimore, Maryland (by invitation).

First Executive Session.

MONDAY, JUNE 20

Morning Session

9:00 A.M.

Pes Cavus.
George J. Garceau, M.D., Indianapolis, Indiana.
Malcolm Brahms, M.D., Indianapolis, Indiana (by invitation).

Tibio-Peroneal Tenoplasty for Treating Certain Cases of Congenital Club-Foot in Young Children.
Juan Farill, M.D., Mexico D. F., Mexico.

The Function of the Peroneal Muscles in the Equinovalgus Foot.
J. Leonard Goldner, M.D., Durham, North Carolina (by invitation).
C. Edwin Irwin, M.D., Warm Springs, Georgia.

Tendon Transplantation for the Correction of Paralytic Calcaneus Deformity.
William T. Green, M.D., Boston, Massachusetts.
David S. Grice, M.D., Boston, Massachusetts.

A Clinical Evaluation of Muscle Transplantation in the Paralytic Foot.
Lee Ramsay Straub, M.D., New York, N. Y.

Studies on the Fibrogenesis of Collagen.
Jerome Gross, M.D., Cambridge, Massachusetts (by invitation).

TUESDAY, JUNE 21

Morning Session

9:00 A.M.

The Anatomy of Lumbosacral Posterior Primary Divisions and Sino-Vertebral Nerves, with an Experimental Study of Their Functions.
Herbert E. Pedersen, M.D., Detroit, Michigan (by invitation).
Conrad F. J. Blunck, M.D., Detroit, Michigan (by invitation).
Ernest Gardner, M.D., Detroit, Michigan (by invitation).

End-Results in Compression Fractures of the Vertebrae with Special Reference to the Intra-Osseous Arterial Circulation.
Edgar M. Bick, M.D., New York, N. Y.

Circumduction Fusions.
David M. Bosworth, M.D., New York, N. Y.

The Mechanical Response in Normal and Degenerated Lumbar Discs.
Carl Hirsch, M.D., Stockholm, Sweden (by invitation).

Presidential Address.
J. Warren White, M.D., Honolulu, Hawaii.

Evening

Annual Banquet.

WEDNESDAY, JUNE 22

Morning Session

9:30 A.M.

Hip Arthrodesis with Subtrochanteric Osteotomy.
Frederick R. Thompson, M.D., New York, N. Y.

Experiences with Lengthening of the Femur over an Intramedullary Pin.
Frederic C. Bost, M.D., San Francisco, California.
Loren J. Larsen, M.D., San Francisco, California.

Medullary Fixation of Forearm Fractures.
Hugh Smith, M.D., Memphis, Tennessee.

Second Executive Session.

Dr. Leo Mayer has been elected an Honorary Member of the *Deutsche Orthopädische Gesellschaft.*

The Annual Meeting of the **American Academy for Cerebral Palsy** will be held under the presidency of Dr. Lenox D. Baker in Memphis, Tennessee, October 10, 11, and 12, 1955. The meetings are open to members of the medical profession and allied professions who are interested in cerebral palsy. The three-day program will include instructional courses in the various phases of cerebral palsy and its treatment, as well as a formal scientific program. Those who wish to attend may obtain an invitation from Dr. Robert A. Knight, 869 Madison Avenue, Memphis 3, Tennessee. Hotel reservations are to be made directly with Mr. Scott Stewart, Manager of the Claridge Hotel, Memphis, Tennessee, which is convention headquarters.

The American Board of Orthopaedic Surgery has announced that the final date for filing application for the Part II examination to be given in January 1956 is August 15, 1955. Application should be made to Dr. Harold A. Sofield, Secretary, 116 S. Michigan Avenue, Chicago 3, Illinois.

At a recent meeting of the **Sociedad Nacional de Cirugia** of Cuba, the following officers were elected for the year 1955:

President: Dr. Julio Sanguily Quintana;
Vice-President: Dr. Gustavo Cuervo Rubio;
Secretary: Dr. Hilario Anido Fraguío;
Vice-Secretary: Dr. Juan Bolivar Ferrer;
Treasurer: Dr. Luis Ajamil Valverde;
Vice-Treasurer: Dr. Antonio Carbonell Salazar.

The Annual Meeting of the **Mid-Central States Orthopaedic Society** will be held at the St. Louis Medical Society Auditorium, St. Louis, Missouri, April 15 and 16, 1955. Headquarters of the Meeting will be at the Sheraton Hotel, St. Louis.

The Manual of Orthopaedic Surgery published by The American Orthopaedic Association with the cooperation of The American Academy of Orthopaedic Surgeons was made possible by the John R. Thompson Fund. This handbook has received enthusiastic acceptance by students, residents, and others who come in contact with orthopaedic problems. During the two years which have elapsed since publication, over 11,000 copies have been distributed.

Much interest in translations of the Manual has been expressed by Spanish, French, Portuguese, and Japanese orthopaedic surgeons.

The present Manual is distributed at cost. When it becomes self-supporting, the John R. Thompson Fund will be directed to the support of other educational activities in the field of orthopaedic surgery.

The Manual of Orthopaedic Surgery may be obtained for $1.08 per copy, with a discount of 15 per cent. for single orders of ten or more copies. Orders should be sent to the Central Office of The American Academy of Orthopaedic Surgeons, Inc., 122 South Michigan Avenue, Chicago 3, Illinois.

MEDICAL SOCIETY OF THE STATE OF NEW YORK
SECTION ON ORTHOPAEDIC SURGERY

The Orthopaedic Section of the Medical Society of the State of New York will hold its Annual Meeting, under the chairmanship of Dr. William E. Gazeley, in Buffalo, New York, May 11, 1955. The program will be as follows:

9:00 A.M.

Vertebral Body Autopsy.
F. S. Craig, M.D., New York, N. Y.
Discussion by Harrison L. McLaughlin, M.D., New York, N. Y.

Repair of Hernias through Iliac Crest Defects.
David M. Bosworth, M.D., New York, N. Y.
Discussion by F. L. Liebolt, M.D., New York, N. Y.

10:00 A.M.

Executive Session
Election of Officers.
Report of Delegate, F. L. Liebolt, M.D., New York, N. Y.

The Surgical Management of Shoulder Conditions.
H. F. Moseley, M.D., Montreal, Canada (by invitation).

The Conservative Management of Shoulder Conditions.
A. A. Michele, M.D., Brooklyn, New York.
Discussion by Harrison L. McLaughlin, M.D., New York, N. Y.
Robert L. Patterson, Jr., M.D., New York, N. Y.

Primary Vertebral Osteophytosis.
E. M. Bick, M.D., New York, N. Y.
Discussion by F. R. Thompson, M.D., New York, N. Y.
R. D. Severance, M.D., Syracuse, New York.

AMERICAN MEDICAL ASSOCIATION
SECTION ON ORTHOPAEDIC SURGERY

The Section on Orthopaedic Surgery of the American Medical Association will meet at Atlantic City, New Jersey, on Tuesday, June 7, 8, and 9, 1955. The officers of the Section are:

Chairman: Jesse T. Nicholson, M.D., Philadelphia, Pennsylvania
Vice-Chairman: William T. Green, M.D., Boston, Massachusetts
Secretary: Frederick R. Thompson, M.D., New York, N. Y.
Executive Committee: H. Relton McCarroll, M.D., St. Louis, Missouri
Charles N. Pease, M.D., Chicago, Illinois
Jesse T. Nicholson, M.D., Philadelphia, Pennsylvania
Frederick R. Thompson, M.D., New York, N. Y.
Edward L. Compere, M.D., Chicago, Illinois

The tentative Program includes the following papers:

TUESDAY, JUNE 7

Morning Session

9:00 A.M.

Traumatic Dislocation of the Head of the Radius in Children.
F. H. Stelling, M.D., Greenville, South Carolina.
Richard Cote, M.D., Greenville, South Carolina.
Discussion by Francis W. Glen, M.D., Miami, Florida.
John H. Aldes, M.D., Los Angeles, California.

The Importance of Routine Pre-Employment Examinations of the Back.
Rex L. Dively, M.D., Kansas City, Missouri.
Rial R. Oglevie, M.D., Kansas City, Missouri.
Discussion by Leonard T. Peterson, M.D., Washington, D. C.
Charles Romboldt, M.D., Wichita, Kansas.

Vertebral Osteophytosis. A Clinical Syndrome.
Edgar M. Bick, M.D., New York, N. Y.
Discussion by John Hamilton Allan, M.D., Charlottesville, Virginia.
Arthur F. Seifer, M.D., Philadelphia, Pennsylvania.
Fractures of the Humerus. Ambulatory-Traction Technique.
Hira E. Branch, M.D., Flint, Michigan.
Discussion by Charles N. Pease, M.D., Chicago, Illinois.
Edward M. Winant, M.D., New York, N. Y.
Delayed Closure of Compound Fractures.
Donald T. Imrie, M.D., Vicksburg, Mississippi.
Discussion by Arthur A. Thibodeau, M.D., Boston, Massachusetts.
Clyde W. Dawson, M.D., Columbus, Ohio.
Management of Pathological Fractures and Long-Bone Fractures of Paraplegic Patients.
Robert Lee Patterson, M.D., New York, N. Y.
S. N. Eichenholtz, M.D., New York, N. Y.
Discussion by Paul C. Colonna, M.D., Philadelphia, Pennsylvania.
R. A. Murray, M.D., Temple, Texas.

WEDNESDAY, JUNE 8

Morning Session

9:00 A.M.

Election of Officers.
Division of the Tibial Collateral Ligament for Removal of the Medial Meniscus from the Knee Joint.
Julius S. Neviaser, M.D., Washington, D. C.
Discussion by H. Relton McCarroll, M.D., St. Louis, Missouri.
Roy I. Peck, M.D., Philadelphia, Pennsylvania.
The Role of the Orthopaedic Surgeon in the Treatment of Cerebral Palsy.
Frederick C. Bost, M.D., San Francisco, California.
R. Kirklin Ashley, M.D., San Francisco, California.
Warren J. Kelley, M.D., San Francisco, California.
Discussion by Sidney Keats, M.D., South Orange, New Jersey.
Lenox D. Baker, M.D., Durham, North Carolina.
Chairman's Address. The Physician and Compensation Patients.
Jesse T. Nicholson, M.D., Philadelphia, Pennsylvania.
Whiplash Injuries. I. Subluxations of the Cervical Spine.
Leo Arthur Green, M.D., Forest Hills, New York.
Discussion by Walter L. Bailey, M.D., Wilmington, Delaware.
Harry M. Salzer, M.D., Cincinnati, Ohio.
Posterior Dislocation of the Shoulder.
Sylvester J. O'Connor, M.D., Ann Arbor, Michigan.
Albert S. Jacknow, M.D., Ann Arbor, Michigan.
Discussion by Frederick M. Smith, M.D., New York, N. Y.
Dana M. Street, M.D., Memphis, Tennessee.

THURSDAY, JUNE 9

Morning Session

9:00 A.M.

Acquired Torticollis in Children and Young Adults.
John S. Donaldson, M.D., Pittsburgh, Pennsylvania.
Discussion by Emanuel B. Kaplan, M.D., New York, N. Y.
J. William Fielding, M.D., New York, N. Y.
Meniscus Injuries of the Temporomandibular Joint.
Carroll M. Silver, M.D., Providence, Rhode Island.
Stanley D. Simon, M.D., Providence, Rhode Island.
Americo A. Savastano, M.D., Providence, Rhode Island.
Discussion by David M. Bosworth, M.D., New York, N. Y.
Edward L. Compere, M.D., Chicago, Illinois.
Intra-Articular Osteocartilaginous-Joint Bodies. Pathogenesis and Clinical Management.
J. Vernon Luck, M.D., Los Angeles, California.
Discussion by George L. Inge, M.D., Knoxville, Tennessee.
Carter R. Rowe, M.D., Boston, Massachusetts.

Arthropathy in the Hemophiliac Patient.
A. F. DePalma, M.D., Philadelphia, Pennsylvania.
J. M. Cotler, M.D., Philadelphia, Pennsylvania.
Discussion by J. I. Kendrick, M.D., Cleveland, Ohio.
Lee Ramsay Straub, M.D., New York, N. Y.
Early Diagnosis and Prognosis of Non-Union of the Femoral Neck with the Aid of Laminagraphy.
Norman J. Rosenberg, M.D., Cleveland, Ohio.
Rudolph S. Reich, M.D., Cleveland, Ohio.
Discussion by Nicholas A. Giannestras, M.D., Cleveland, Ohio.
J. Royal Moore, M.D., Philadelphia, Pennsylvania.
Fractures of the External Humeral Condyle.
Henry Milch, M.D., New York, N. Y.
Discussion by George R. Miller, M.D., Gastonia, North Carolina.
Ralph E. Ingersol, M.D., Boston, Massachusetts.

THE EXCHANGE FELLOWS

The Committee on Exchange Fellows of The American Orthopaedic Association met in Los Angeles on January 29 to select the four candidates from the United States who will travel to Great Britain in 1955. As there were seventy-one applicants to consider, the task of the Committee was not easy, especially since a very large proportion of the applicants were men of high attainments. Careful consideration was given to every aspect of each candidate's qualifications. It was necessary to interpret strictly the regulations regarding age and Board qualifications. Other things being equal, some preference was accorded to candidates from areas which were not represented by Fellows in the 1949 group.

The Fellows finally selected by the Committee and approved by the Executive Committee of The American Orthopaedic Association are the following:

Dr. Daniel C. Riordan, 1538 Louisiana Avenue, New Orleans, Louisiana;
Dr. Albert B. Ferguson, Jr., Children's Hospital, Pittsburgh, Pennsylvania;
Dr. Charles F. Gregory, 23 East Ohio Street, Indianapolis, Indiana;
Dr. J. Leonard Goldner, Duke Hospital, Durham, North Carolina.

The Exchange Committee of The Canadian Orthopaedic Association met on February 2 and selected Dr. Cameron Allen of Vancouver, British Columbia, as their representative.

The five Exchange Fellows will leave New York on April 20 on the Queen Elizabeth and will return to New York on the Queen Elizabeth on June 14. The Presidents of both The American Orthopaedic Association and The Canadian Orthopaedic Association are inviting their Fellows to attend the annual meetings of their respective Associations during the last week in June.

CORRECTION

An error occurred in the article by Dr. William J. Tobin published in the January 1955 issue of *The Journal*. The cut which appears as Figure 4-C on page 59 should have been printed with the present base at the top. It is suggested that *Journal* readers mark this page of the January issue, indicating that this illustration is upside down.

Book Reviews

Resection-Reconstruction of the Hip. Arthroplasty with an Acrylic Prosthesis. Jean Judet, Robert Judet, Jean Lagrange, and Jean Dunoyer. Edited by K. I. Nissen. Edinburgh, E. & S. Livingstone, Ltd.; Baltimore, The Williams & Wilkins Co., 1954. $7.00.

It is impossible for any exposition of a medical subject of such universal interest and as fluid as this to be completely up-to-date at the time of its publication. Herein lies the only real criticism of the Judets' monograph. There was, unfortunately, a considerable time lag between the date of its publication in France (1952) and its translation into English and its publication in England (1954). In the meantime, the Judets have brought out their new "oblique" prosthesis, leaving orthopaedists the world over in a quandary as to the exact status of the original prosthesis and what use to make of the new oblique prosthesis. In an effort to resolve this confusion, I have communicated directly with one of the authors (Dunoyer) for information as to the current opinions and practices of the Judet Clinic in Paris.

This monograph should be studied thoroughly by every orthopaedist who wishes to perform any type of prosthetic arthroplasty of the hip, or, as the Judets term it, a resection-reconstruction operation. It is concise, well written, well translated, and easy to read. The authors discuss frankly the errors and pitfalls, as well as the good points, of the procedure. They have systematically evaluated their results by means of the Howorth-Merle d'Aubigné method. The reviewer would, incidentally, suggest that, in the future, all reports of results of reconstruction-arthroplasty of the hip should be evaluated by this method in order to permit accurate comparison of results. The technical details of book manufacture are satisfied in the usual excellent manner of the publishers, E. & S. Livingstone, Ltd.

In order to orient the reader as to the Judets' current opinions, Dr. Dunoyer has kindly supplied the following information: In fresh and ununited fractures of the neck of the femur, the new oblique prosthesis cannot be used. The old prosthesis is still used for this group of patients, with the best results of all the groups. The Judets do not use the medullary type of prosthesis, for "failures are much more difficult to manage than if one still has a cervical stump". In hips which are the site of an osteo-arthritis, with cystic changes in the femoral head, they believe that the oblique prosthesis should be used. If the bone of the inferior portion of the femoral head is severely damaged, the cystic areas are packed with cancellous bone. In two instances, following removal of an old prosthesis, a thick cancellous-bone graft was used to lengthen the femoral neck. The bone was, of course, shaped at 60 degrees on the medial side in order to fit the oblique type of prosthesis. In both patients, the current roentgenograms show good healing, and the early result is good. Dr. Dunoyer points out that there are many problems still to be solved and cautions that the orthopaedist "must be very careful" in recommending the resection-reconstruction procedure.

Robert A. Knight, M.D.

Abdominal Fascial Transplants. Charles L. Lowman, M.D. Privately printed, 1954.

This brief monograph (eighty-eight pages) by the chief exponent of the fascial graft as applied to paralytic lesions of the abdominal wall should stimulate further interest in this important topic and should help to make the insertion of fascial grafts an effective method of combatting what Lowman aptly terms "a break in the kinetic chain". The author does not attempt a detailed review of the many patients operated upon by him and his staff since his first presentation in 1932 before The American Orthopaedic Association. Rather he gives a bird's-eye view of the entire subject from the position of vantage gained by many years of observation and practice. Of particular interest is Lowman's masterly analysis of the kinesiology of the abdominal musculature, to which Dr. Steindler, in his introduction, refers as "a real monument in kinetic analysis". The chapters dealing with operative technique and postoperative care give explicit directions which should be invaluable not only to the newcomer in this field of surgery but also to those who have had extensive experience in fascial transplants.

This reviewer was greatly impressed by Lowman's acknowledgement of his indebtedness to the research of Dr. Murray Gratz. He quotes Gratz extensively in the chapter dealing with "Histological and Experimental Studies" and states that, in accordance with Gratz's criticism of the original method of suturing the transplant to the sides of the opened sheath of the rectus, he has discarded this method and "run the fascial strips through a subcutaneous tunnel" (p. 2). The six illustrative cases, with which the monograph closes, substantiate the author's contention that the operations he has designed are of great practical usefulness in the rehabilitation of severe trunk disabilities.

Although one of the first cases, reported in 1932, had "difficulty in lifting the right side of the pelvis enough to get her foot off the ground" and "the pelvis sagged down on the right, making the right leg seem longer" — obviously a case of fixed paralytic pelvic obliquity due to paralysis of the right abdominals and probably of the quadratus lumborum — Lowman throughout his book studiously avoids the use of the

term "fixed paralytic pelvic obliquity". Why he does not accept this concept is not explained in the text; certainly many of his cases must have fallen into this category. Further clarification on this point will, we hope, be forthcoming in subsequent publications by Lowman and his associates.

Leo Mayer, M.D.

GRENZEN DES NORMALEN UND ANFÄNGE DES PATHOLOGISCHEN IM RÖNTGEN DES SKELETTES. 9. Aufl. Prof. Dr. A. Köhler. Revised by Doz. Dr. E. A. Zimmer. Stuttgart, Georg Thieme Verlag, 1953. DM 88.

Köhler of Vienna, one of the true pioneers among the early roentgenologists, published the First Edition of this book in 1910; it was then called by another great roentgenologist, Goesta Forssell, "the lexicon of radiology".

This book, describing and illustrating the many variations from the normal and the beginning of the abnormal, has maintained its original importance over the years and still is one of the classics of roentgenological literature. This Ninth Edition has been edited and almost completely revised by Zimmer.

To review such a comprehensive book is really an enjoyable task. In contrast to most of the earlier editions, the new book deals exclusively with the bony structures. All chapters have been extensively enlarged. A vast amount of new information has been added and numerous new and remarkable illustrations and sketches have been interspersed throughout the text. The quantity and quality of the many reproductions of roentgenograms, demonstrating even minute and rare deviations from the normal and conditions often completely unsuspected, are really astounding.

Such a book is not intended to be a textbook but to be thought of as a reference for study when one is confronted, as he not uncommonly is, with doubtful appearances in which the borderline must be determined between the possibly normal and a pathological process.

This book is subdivided in a fashion which will make it easy for the reader to find what he wishes to know about problems in question. Various chapters discuss conditions pertinent to individual parts of the body, while others deal with the more general problems which may arise in systemic, developmental, or metabolic disturbances, which are commonly found in groups of bones as manifestations of general disease. These subdivisions can be found easily because of the organization of the text. A separate index adds to the usefulness of this book. Those who have to study specific problems beyond the scope of the text may be helped greatly by the many references and a satisfactory bibliography.

The importance of such a book will be apparent when one considers the many roentgenographic problems in insurance or compensation cases today which may demand interpretation in matters of litigation.

This book in its former editions has always been considered an essential part of any roentgenologic library; certainly, the supplemental information found in the newest edition emphasizes this even more.

H. Peter Mueller, M.D.

SURGERY. Edited by Sir Zachary Cope, B.A., M.D., F.R.C.S. (History of the Second World War. United Kingdom Medical Series. Editor-in-Chief: Sir Arthur S. MacNalty, K.C.B., M.D., F.R.C.P., F.R.C.S.) London, Her Majesty's Stationery Office, 1953. 4 pounds.

This thick volume covers not only the advances made in surgery during the War but also the problems of logistics, organization, and improvisations imposed by the various aspects of total war. A good deal is also said about the surgery of World War I and the surgical advances between the two world wars.

The book is a masterpiece of condensation and arrangement. Of the twenty-five chapters, by far the longest are those on neurosurgery and abdominal wounds. The third longest deals with orthopaedic surgery. Seven pages are devoted to a chapter on the traumatic effects of the atomic bomb as understood up to 1949, the most recent date mentioned in the references. The inclusion of this quasi-theoretical chapter at the expense of subjects about which a wealth of first-hand knowledge is available may be open to question. However, let the critic who has succeeded in packing more useful information into a better arranged book throw the first stone.

Easy readability gives this book a virtue not always found in medical works, particularly in medical compilations. Despite the large number of contributors, the style throughout is pleasantly informal, often almost conversational, and always direct and unaffected. Historical allusions and philosophical speculations are included when they serve to illuminate the subject.

A purely insular or British viewpoint has been avoided, as is required by the universality of the theme. Many familiar American names appear in the bibliographies. *The Journal of Bone and Joint Surgery* is frequently mentioned, and readers of this Journal will find the sections on Orthopaedic Surgery, Amputations and Artificial Limbs, and Physiotherapy and Rehabilitation of particular interest.

The chapter entitled "Prisoner-of-War Camp Surgery" describes, with what must be extreme understatement even for an Englishman, examples of surgery under appalling conditions.

We sometimes hear the cynical observation that war surgery is nothing but peacetime surgery badly done by people in uniform. Sir W. Heneage Ogilvie points out in his introduction, "A fallacy that appears

in all literature on war surgery is that war surgery and traumatic surgery are synonymous. . . . War surgery is traumatic surgery applied under conditions of war, and the conditions cannot be dictated or modified by the surgeon, or even by the high command. . . . Efficiency in war surgery means the best possible treatment of casualties compatible with winning the war, but if anything is allowed to interfere with military efficiency, the lives of well and wounded are risked alike. . . . Military efficiency at times of hard fighting means speed, simplicity and concealment, and surgical units . . . under these conditions must be content with small numbers, limited supplies, light equipment, and simple methods."

The Atomic Age, which has deprived our country of its old geographical security, gives a grim immediacy to these words. In fact, the whole book has more than historical and scientific interest for American surgeons at the present time.

Horatio Rogers, M.D.

NASH'S SURGICAL PHYSIOLOGY. Ed. 2. Edited by Brian Blades, M.D. Springfield, Illinois, Charles C. Thomas, 1953. $12.50.

The purpose of this book is to present those aspects of physiology which are important to surgeons. It is not designed, however, to be a comprehensive textbook of physiology; hence, the practical aspects with which it deals might be considered as the essentials of basic science which all students of surgery should know.

To those of us who are orthopaedic surgeons, much of this book makes interesting reading. It is simply a means of being brought up-to-date in other surgical specialties. For example, excellent discussions on cardiac surgery in congenital heart disease and the problem of cardiac arrest are presented.

There are some sections which seemingly are of less interest to those in orthopaedic surgery, such as the section on the gastro-intestinal tract. However, a good understanding of the mechanics of the absorption of calcium and phosphorous is quite useful to the orthopaedic surgeon; it is well presented in this section.

There are certain other sections which are highly recommended to all orthopaedists. For example, the reviews of the kidney, of electrolyte balance, of the role vitamins play in surgery, and of wound healing are well presented.

Of especial interest are the chapters on neurophysiology, on blood vessels, and on the relation of blood vessels to various abnormalities in the circulation of extremities with which all of us must contend.

The one criticism of the book is that it has not been written especially for the orthopaedic surgeon. He has to wade through each section in order to extract those facts which may be of especial interest to him. It may be that this is the great charm of such a publication, for it will re-orient the reader to the fact that basically he is a surgeon and cannot, therefore, confine himself to some special field.

Finally, for those men who are preparing for examinations and for those engaged in research, *Nash's Surgical Physiology* should be required reading.

James A. Nicholas, M.D.

FLUIDS AND ELECTROLYTES IN PRACTICE. Harry Statland, M.D. Philadelphia, J. B. Lippincott Company, 1954. $5.00.

A primary factor in reducing the operative risk to the patient is efficient preoperative and postoperative use of fluids and electrolytes. The application of surgery to older people with their renal and cardiac complications, to more and frequent traumatic problems which also include large fluid losses, and to infants in whom the margin for error in fluid therapy is small is constantly being extended. To accommodate to these changing conditions, the modern surgeon needs to refine his understanding of the balance of fluid and electrolytes and the ways of treating its disturbance. To acquaint those practitioners who desire a modern, simple, and practical approach to the subject, Dr. Statland has revised a series of lectures which he had given to undergraduates and postgraduate students. He has achieved extraordinary success in condensing his subject to a form which is easily assimilated, and yet which contains the essential data.

He begins with a consideration of the elementary concepts, such as fluid compartments, milliequivalents, and milliosmols, and proceeds to consider, in order, the normal physiology of fluid and electrolyte balance, disturbance of this balance and how to adjust it, and finally such special conditions as burns, diarrhoea, and pediatric problems. All of this is done without the use of complicated graphs and with the judicious use of simple figures and examples. The bibliography is excellent. It is up-to-date, carefully selected, and represents a remarkable achievement in these days when, especially in this field, the flood of radio-active tracer studies inundates journals and general readers alike.

It is with pleasure that I recommend this book to surgeons, particularly those who have been in practice for ten years or more. It is easily read and is an excellent guide, especially for those who only occasionally have a difficult problem in fluid therapy.

Jonathan Cohen, M.D.

McFadyean's Osteology and Arthrology of the Domesticated Animals. Ed. 4. Edited by H. V. Hughes, B.V. Sc., M.R.C.V.S., D.V.H., and J. W. Dransfield, M.V.Sc., M.R.C.V.S. London, Baillière, Tindall and Cox, 21 shillings; Baltimore, The Williams & Wilkins Co. 1953. $5.00.

The first English edition of this 288-page book appeared in 1887. Two editions were published subsequently during the lifetime of Dr. McFadyean, the last being in 1934. The present edition, edited by Hughes and Dransfield of the University of Liverpool School of Veterinary Medicine, has brought the material of the book up-to-date. There have been no radical changes in the book. The drawings have been increased from 151 to 205 and have all been prepared by Dr. Dransfield. In the illustrations, particular attention has been paid to the bones and joints of the ox, pig, cat, and dog. The original drawings had been prepared from laboratory specimens. As the horse is the most valuable type of animal for study in veterinary anatomy, the greatest amount of the material of the book is devoted to the description of the bones and joints of this animal. The nomenclature has been brought into line with modern thinking and more attention has been given to a discussion of the development of bone.

In the first chapter of general considerations, there is a very excellent description of the classification, structure, physical properties, chemical composition, and development of bones and soft structures associated with bones. The book then goes into a separate description of the vertebral column, the ribs and sternum, the skull, the forelimb, and hindlimb in each animal. In addition in the section on osteology, there is a description of the bones of the domesticated fowl. The section on osteology is more than three times as large as that devoted to arthrology.

The book is extremely well written and well prepared. It should be of value to those interested in comparative anatomy and to those doing experimental work with any of these types of domesticated animals. It should be in the library of every orthopaedic research department.

A. R. Shands, Jr., M.D.

Year Book of Orthopedics and Traumatic Surgery (1953–1954 Year Book Series). Edited by Edward L. Compere, M.D., F.A.C.S., F.I.C.S. Chicago, The Year Book Publishers, 1954. $6.00.

The 1953–1954 edition of this now well known review maintains the high standards of previous volumes. The organization and format remain unchanged. The 339 text pages contain abstracts from the world literature. Much information in a concise form is available and this little book serves as a ready reference for those desiring to find current articles dealing with orthopaedics and traumatology. As in the past, this book is recommended particularly to the busy surgeon with little time to browse through current periodicals.

Thornton Brown, M.D.

Diagnosis and Treatment of the Acute Phase of Poliomyelitis and Its Complications. Edited by Albert G. Bower, M.D. Baltimore, The Williams & Wilkins Co., 1954. $6.50.

This is an excellent book concerning the treatment of patients with respiratory and bulbar paralysis occurring in the acute phase of poliomyelitis. The various chapters have been written by the Staff of the Los Angeles County Hospital who have treated large numbers of respiratory and bulbar poliomyelitic patients. The book summarizes their experiences and the many contributions they have made in the treatment of these patients.

It is not a book concerned with the management of acute poliomyelitis, however, and in the chapter on the medical management of the patients, there are only sixteen lines devoted to the management of the patient without respiratory involvement and fourteen pages to the care of the bulbar and respiratory poliomyelitic patient. This is not a criticism of the book, which is well written and covers the diagnosis and treatment of bulbar and respiratory poliomyelitis very well. The title of the book is misleading, and anyone interested in the diagnosis and management of acute and early convalescent poliomyelitis will be disappointed in it.

Inasmuch as the most important phase of treatment of acute poliomyelitis is the treatment of respiratory and bulbar poliomyelitis, the book is a valuable contribution and will be of particular interest to the internist and pediatrician who are concerned with the medical management of acute poliomyelitis.

David S. Grice, M.D.

Maladies des Os et des Articulations. Stanislas de Sèze et Antoine Ryckewaert. Paris, Éditions Médicales Flammarion, 1954. fr. 9,300.

When one compares this textbook on the diseases of the skeleton with others of recent date, one is impressed by the ability of the authors to present concise and up-to-date summaries of most of the subjects which engage their attention. This is particularly true for the first half of the volume which deals with the diseases of bone. Here nearly all of the known entities (including rare ones) are well described, with the emphasis on pathology, both morphological and physiological. The chapters on the effects of metabolic

diseases of bone may be singled out for special commendation. Also to be commended is the authors' policy to discard the obsolete, which so often encumbers textbooks, even those which have undergone many revisions. However, a few improvements would be desirable before this book can be unqualifiedly recommended to readers of more sophistication than the medical student and intern. First, in the matter of coverage, the outstanding hiatus, which will disturb the orthopaedic surgeon, is the lack of any chapters on trauma. Minor omissions also are evident, such as a discussion of slipped epiphysis and of arthrogryposis. A chapter on congenital deformities would have been welcome. The emphasis in this portion of the book is on pathology. Treatment is only indicated in a general way, but the therapeutic armamentarium listed is quite modern and complete.

The second portion of the book, concerned with diseases of the joints, has the merit of presenting in detail the modern and frequently controversial aspects of the pathogenesis of articular changes and their treatment. In this section, much more information concerning therapy is included than in the first section. This shift in emphasis, the inclusion of details of treatment, does not diminish the value of this section since the material given is modern, detailed, and applicable. However, such a shift does raise the question in the mind of the reviewer as to the nature of the public to which this treatise is directed. Judging by the predominantly French bibliography and the omission of many classical references to which allusions have been made, I suppose that the French medical student would benefit most by this book.

Finally a comment must be made on physical make-up. The quality of the paper is so good that one would have expected better reproduction of x-rays; the few photomicrographs which have been included also could have been of better quality. The book is very heavy (nearly eight pounds), owing to metal loose-leaf construction; I would have preferred a division into two more manageable segments.

Jonathan Cohen, M.D.

Die Narkose. Ein Lehr- und Handbuch. Prof. Dr. H. Killian und Prof. Dr. H. Weese. Stuttgart, Georg Thieme Verlag, 1954. DM 170. ($40.50).

This book is the first major German publication on modern anaesthesia. The authors are the late H. Weese and H. Killian, both of whom have done a considerable amount of research in anaesthesia and in related fields. H. Weese who died in an accident last year, introduced evipal sodium as an intravenous barbiturate shortly before pentothal sodium was introduced by Lundy in this country. Evipal was almost exclusively used as an intravenous anaesthetic agent in Europe up to the War. Weese also developed polyvinylpyrrholidone, a plasma expander, which was used extensively by the Germans during the War and which probably saved a considerable number of lives.

The work contains several chapters on specific subjects written by various other authors, but the larger part of the book has been written by Killian and Weese.

The wisdom of two men undertaking a venture, such as a book of this scope, is somewhat questionable. The field is large since it involves cardiovascular physiology, metabolic physiology, endocrinology, and a certain amount of neurophysiology, as well as the practical problems and methods of clinical anaesthesiology.

Aside from a review of the history of anaesthesia, the book is divided roughly into two parts: the first, a theoretical part, concerns the cardiovascular, metabolic, and neurophysiological aspects of anaesthesia; the second deals with the practical sides of the specialty.

Unfortunately, the first part has a limited usefulness to the reader. It contains a tremendous number of references and data which are quite out of date considering the research which has been done since. The modern literature is represented, but sometimes only rather scantily. For some chapters, there are almost no recent references at all. The worst defect is that very little effort has been made to corroborate the material presented and to outline concisely the concepts underlying the data presented. This may be in line with the standards of a *Handbuch*, but it is quite an omission in a *Lehrbuch* (textbook).

Certain physiological entities, the principles of which, when transferred into clinical practice, may mean life or death to a patient, are described in a fashion which would be considered outmoded by the American reader. To cite some obvious examples, the reviewer would like to mention Killian's concept of pulmonary oedema with its emphasis on morphological changes in the lung (not in relation to any damage) and its overestimation of the primary role of the nervous system in causing pulmonary oedema. The mediating role of sympathetic epinephrine and nor-epinephrine release has not been very well understood by Killian.

The concept of the "cardiovascular center", as the direct regulatory mechanism of the cardiovascular system, would not be accepted here either; the concept of vegetative dystonia in which a "vagotonus" and a "sympaticotonus" predominate is equally unacceptable. The other theoretical chapters contain similar, if not so obvious, defects in the subject matter presented.

The technical part on the practical aspects of anaesthesia is adequate and up-to-date. It contains a chapter on anaesthesia machines and technical equipment which is usually not so thoroughly presented in English textbooks.

There is also a chapter on the "exclusion of the vegetativum", a rather nebulous and unfortunate

term the meaning of which includes the principle of the use of ganglionic-blocking agents, as well as the use of "artificial hibernation" — a type of anaesthesia now popular in Europe. Artificial hibernation is considered in America, England, and also in France (from which it originates) as of highly dubious value, since the whole concept of "excluding the vegetativum" in order to eliminate the response toward "aggressions" is a romantic rather than a scientific approach to the problem, fascinating though the idea may at first seem.

The claims of Laborit and Hugenard have by no means been substantiated as yet by well controlled experiments. The only controlled experiments embarked upon were those done by English workers; these could not substantiate most of the theories of Laborit and Hugenard. It is surprising that the authors have accepted this type of anaesthesia as enthusiastically as they have. The evidence they produce in their book is certainly not very convincing.

This book will supply the reader with reliable information in regard to the practical side of anaesthesiology. As far as the theoretical part goes, the reader will need to maintain a critical attitude toward the data and theories presented. It is unfortunate that this book will become the main source of reference within the German language publications, at least for the immediate future.

The printing and general make-up is, as is true of most German publications, excellent.

Kurt Schmidt, M.D.

Surgical Infections. Prophylaxis, Treatment, and Antibiotic Therapy. Edwin J. Pulaski, M.D., D.M.Sc. (Surgery), Lt. Col. M.C., U.S.A. Springfield, Illinois, Charles C. Thomas, 1954. $7.75.

This monograph is one of the American Lecture Series. The subject matter deals with general considerations regarding the role of antibiotics in surgery. The material is divided into seven chapters; at the end of each is a short bibliography.

The approach and management of the material presented is that of the well informed general surgeon who views antibiotic therapy in its proper role with the full realization that it is not a substitute for time-tried surgical methods. The general considerations in antibiotic therapy are reviewed in the opening chapter. The remaining chapters are devoted to discussions of the management of specific and regional infections. There is a long discussion of the management of burns, as well as of civilian and war-incurred injuries.

In general, the subject matter is covered in a somewhat superficial manner, indicating that the material is directed toward the general surgeon with no special interest in surgical infections.

There are several points which are worthy of comment. The author recommends procaine penicillin in oil suspension as preferable to that in aqueous suspension. There is no clear-cut indication that clinical results are better with the use of the oil suspension, and there is ample evidence to indicate that local allergic reactions to the oil may occur. The latter far outweigh the rather slight inconvenience of having to suspend the procaine penicillin crystals in water just prior to its use.

In the treatment of meningitis with intrathecal streptomycin, it is generally felt that dosage with 25 milligrams should not be exceeded; the author suggests dosage of 100 milligrams.

Perhaps most striking is the poor phraseology used which at times confuses the thought that the author wishes to convey. For example, on page 131, one finds the following statement ". . . and it would be expected that antibiotic therapy would not be effective because it does not act upon dead tissue". What the author means to convey is that antibiotics are not able to reach bacteria harbored in dead tissue in an adequate concentration to be effective.

On page 257, one finds "It may well be that the good results of antibiotic therapy in clinical peritonitis can be partly attributed to the prevention of shock and not to their antibacterial effect alone". Obviously antibiotics have no direct effect on the prevention of shock *per se* other than through their antibacterial action.

There are many other ambiguous statements throughout the book which seriously detract from its value to the general surgeon. Such ambiguities could have been eliminated by more rigorous editing.

Lewis W. Kane, M.D.

Kinderorthopädie. Priv.-Doz. Dr. med. habil. R. Bernbeck. Stuttgart, Georg Thieme Verlag, 1954. DM 39 ($9.30).

Orthopaedics, the youngest of the surgical specialties, has made such rapid progress that within its own field other specialties, such as the treatment of paralysis and club-foot and hand surgery, have developed. Children's orthopaedics is one of these specialties, and it is particularly proper that this should be so since Andry, the recognized founder of orthopaedics, derived its very designation from his interest in "straight children".

The author particularly stresses the point that children's orthopaedics is not primarily surgical and that the true art of the orthopaedist is conservative. The operative intervention is indeed only a last resort. The main difference between children's orthopaedics and adult orthopaedics lies in the fact that in children prophylaxis and correction, rather than major surgical intervention, can be employed. "The sapling bends; the tree cannot."

With this objective in mind, the author proceeds, in the first part of the book, to describe briefly the

normal development of a child's skeleton, the special characteristics of its component cartilage and bone, the general pathology of the growing skeleton, and the methods of orthopaedic diagnosis and therapy, including both operative and non-operative methods. The larger part of the work is given over to the consideration of specific conditions in the foot, knee, hip, pelvis, spine, pectoral girdle, and component parts of the upper extremity. As might have been expected, particular attention is directed to the discussion of club-foot and hip dislocations. Despite this special interest, little attention is given to the subject of dysplasia of the hip and still less to the earliest recognition of this condition. The chapter on Perthes' disease is interestingly presented, but the whole subject of osteotomy and axial malalignment is handled in a sketchy and not well organized manner.

Generally speaking the work is a decidedly worth-while addition to the orthopaedic literature, especially for students. As a reference book, its value would have been greatly enhanced by a more extensive bibliography. Although the author has had a tour of several months' study in America, the vast American orthopaedic literature and the point of view of American orthopaedic surgeons, except for a passing reference to Kite, have been overlooked.

While the author has in the main presented the teaching of the Munich School, it hardly seems justified that national consciousness should so far overshadow the international character of orthopaedic surgery as to warrant only one French, one British, and two American references.

Henry Milch, M.D.

ATLAS OF MEN. William H. Sheldon, Ph.D., M.D. With the collaboration of C. Wesley Dupertuis, Ph.D., and Eugene McDermott, M.A. New York, Harper & Brothers, 1954. $10.00.

At long last an *Atlas of Men* is available. There are 357 pages. The pages are of a size large enough to permit adequate illustrations on a single page. These show 1,175 body builds or somatotypes, together with a number of other illustrations and three appendixes. A nomograph and tables, as well as several diagrams are included; these enable the average person to compute a body build from stature and weight determinations without much difficulty. In the application of the index which is obtained from the nomograph readings, which consist of the height divided by the cube root of the weight, there are usually three and sometimes four choices. Accuracy of the typing is assured by consulting the three or four different types and comparing the photographs with the person who is being typed.

The stated principle and purpose of the *Atlas of Men* have been achieved by its authors. By making available a standard file of somatotype variations (body builds), a practical tool is thus presented to the research scientist in genetics, clinical medicine, and social studies. Whether it is later to be modified scarcely matters today. We know that every phase of science is subject to constructive changes. The question of where the particular genotypes fit in with the somatotypes must be left to physical anthropologists who are most interested in this. Actually, we now have in this *Atlas* a controlled series against which we can plot the types which appear in our clinical studies. It is true that this is largely a cross-sectional atlas, but a longitudinal atlas, as the authors state, while more desirable, is next to impossible to achieve. Since clinicians are concerned with the comparison and the correlation of their group studies with those of other investigators, and have found it hitherto almost impossible to compare these by means of purely descriptive texts, they now have a means of accurate comparison.

Human variations are enormous, or so they seem, until a descriptive classification or a taxonomic method is set up by a body-build expert, such as the authors undoubtedly are. Here, the many differences are reduced with great skill to a manageable numerical determination. Sheldon and his associates have divided man into valid body-type units of eighty-eight somatotypes on the seven-point scale. There were 505 body types when they used the one-half scale or a thirteen-point rating. They have arranged the types in the frequency they occurred in their series of 46,000 male subjects between the ages of eighteen and sixty-five years. Incidentally, children may be typed, but their classification has not, at present, been reported.

Normal curves for height, weight, and age are given, and the incidence per 1,000 persons is listed. This alone will be of great value to the clinician, especially in the projectional fields of life, accident, and health insurance. Every medical director of every insurance company will find these materials more valuable than any of the older tables, which they have considered their abacus when deciding the type in which their "applicants" should be placed.

Some will criticize the zoological classification which the authors have used, but I, personally, rather like it. The manner of diagramming a three-dimensional component is excellent, and the curves are of great value. The authors have thrown in, for good measure, in the last paragraph under each description, very valuable information relative to the particular body type in question, as it has come to them. This will be deeply appreciated by clinicians, but must be taken with the reservation that the particular individual typed by them, in their own series, may show other characteristics.

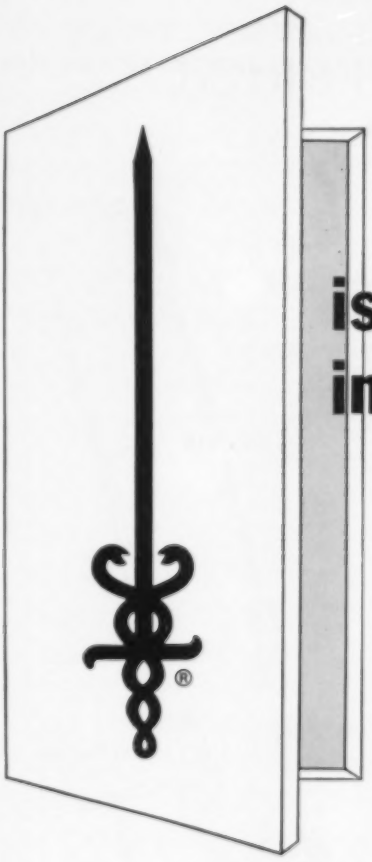
I do not wish to go into the validity of their terminology, except to say that anthropologists are struggling with this phase of somatotyping. One hopes that their work will be fruitful. This Atlas will stand on my desk until a better is forthcoming.

Charles W. Gaff, M.D.

ACKNOWLEDGMENTS

The Journal wishes to acknowledge receipt of the following publications which have been sent to the Editorial Department:

Acta Chirurgica Belgica (Bruxelles), Supplement III, Juin 1954; **53:** Nos. 7, 8, 9, 1954.
Acta Medica et Biologica (Niigata, Japan), **1:** Nos. 3, 4, 1954; **2:** Nos. 1, 2, 1954.
Anales del Servicio de Traumatología del Dr. Lopez-Trigo (Valencia), **9:** Núm. 2, 1954.
The Antiseptic (Madras), **51:** Nos. 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 1954; **52:** Nos. 1, 2, 1955.
Archiv für Japanische Chirurgie (Kyoto, Japan), **23.** Band, 3., 4., 5., 6. Heft, 1954.
Archiva Medica Belgica (Bruxelles), **9:** Fasc. 6, 1954.
Artificial Limbs. A Review of Current Developments (Advisory Committee on Artificial Limbs, National Academy of Sciences—National Research Council, Washington, D. C.), **2:** No. 1, 1955.
Boletín del Instituto de Patología Médica (Madrid), **9:** Nums. 9, 10, 1954.
Boletines de la Sociedad de Cirugía de Rosario (Cordoba, Argentina), **21:** Nos. 6, 7, 1954.
Boletines y Trabajos de la Sociedad Argentina de Ortopedia y Traumatologia (Buenos Aires), **19:** No. 8, 1954.
The Borden Company. Annual Report, 1954.
Bulletin on Current Literature (The monthly bibliography for workers with the handicapped), The National Society for Crippled Children and Adults, Inc. (Chicago), **15:** No. 2, 1954.
Bulletin of the National Society for Crippled Children and Adults, Inc., the Easter Seal Society (Chicago), **16:** No. 11–12, 1954; **17:** No. 10, 1955.
Chinese Medical Journal (Peking), **71:** Nos. 4, 5, 6, 1953.
Cirugía, Ginecología y Urología (Madrid), **8:** Núms. 1–2, 3, 4, 1954.
Cirugia. Revista de Estudios Quirurgicos (Madrid), **1:** No. 2, 1954.
Cleveland Clinic Quarterly (Cleveland), **22:** No. 1, 1955.
The Crippled Child. A magazine for parents (The National Society for Crippled Children and Adults, Inc., Chicago), **32:** No. 4, 1954; **32:** No. 5, 1955.
Comeback (Kessler Institute for Rehabilitation, West Orange, New Jersey), **6:** No. 4, 1955.
Easter Seal Bulletin (The Easter Seal Society, Chicago), **7:** Nos. 1, 3, 1955.
The Gunma Journal of Medical Sciences (Maebashi, Japan), **3:** Nos. 1, 2, 3, 1954.
Harper Hospital Bulletin (Detroit), **12:** Nos. 5, 6, 1954; **13:** No. 1, 1955.
Jikeikai Medical Journal (Minatoku, Tokyo), **1:** No. 1, 1954.
Journal of the Indian Medical Profession (Bombay), **1:** Nos. 5, 7, 8, 1954.
The Journal of the Osaka City Medical Center (Osaka, Japan), **3:** Nos. 1, 1953; **3:** Nos. 2, 3, 4, 1954.
The Keio Journal of Medicine (Tokyo), **2:** Nos. 3, 4, 1953; **3:** Nos. 1, 2, 1954.
The Kumamoto Medical Journal (Kumamoto, Japan), **6:** Nos. 3–4, 1954.
The Kurume Medical Journal (Kurume-Shi, Japan), **1:** No. 2, 1954.
Kyushu Memoirs of Medical Sciences (Fukuoka, Japan), **5:** No. 1, 1954.
Médica (Matanzas, Cuba), **13:** Núm. 4, 1954.
Medical Journal of Osaka University (Osaka, Japan), **5:** No. 4, 1954.
Medical Radiography and Photography (Eastman Kodak Company, Rochester, New York), **30:** No. 3, 1954.
Medicina Practicá (Zaragoza), **12:** Nums. 92, 94, 1954.
The Nagoya Journal of Medical Science (Nagoya, Japan), **17:** Nos. 1, 2, 1954.
Nagoya Medical Journal (Nagoya, Japan), **2:** No. 2, 1954.
PB—Physician's Bulletin (Eli Lilly and Company, Indianapolis), **20:** Nos. 1, 2, 1955.
Revista del Colegio Médico (Habana), **5:** Nos. 1, 2, 1954.
Revista Medica Municipal (Rio de Janeiro), **19:** Nums. 1 e 2, 1954.
Société Savoyarde des Sciences Médicales, Section de Chambery, Savoie. Journées Internationales de Traumatologie du Ski. January 1955.
Wakayama Medical Reports (Wakayama, Japan), **2:** No. 1, 1954.
Western Journal of Surgery, Obstetrics, and Gynecology (Portland, Oregon), **63:** Nos. 1, 2, 3, 1955.
World Medical Journal (New York), **1:** No. 6, 1954.
Yonago Acta Medica (Yonago, Tottori-Ken, Japan), **1:** No. 1, 1954.



is there a doctor in the house?

There certainly is in our house.

Where there is activity against cancer, there is the physician. It is no secret to any of you that the doctor contributes long hours to the needy cancer patient in clinics, in hospitals, in homes. It is your office of which we boast when we say "every doctor's office a cancer detection center."

Less well known is the fact that hundreds of your colleagues, as directors of the American Cancer Society nationally, in Divisions, and with Units, bring the best medical thought to our attack on cancer by education, by research, and by service to patients. The entire professional education program is planned for doctors by doctors.

The occasion for this brief salute is April, the Cancer Control Month. This year, 1955, marks the tenth anniversary of the reorganization of the American Cancer Society and the launching of the post-war attack on cancer. Much has been achieved—far more remains to be done.

We are grateful for your help in the past—and we rely on your continued support. We count heavily on the doctor in our house.

American Cancer Society

In answering advertisements, please mention *The Journal of Bone and Joint Surgery*.

There is a BIG DIFFERENCE between steel braces and UNITED STATES solid ALUMINUM BRACES

Aluminum braces compare with the strength of steel braces and plus added light-weight quality make them ideal for permanent wearers.

United States braces are manufactured from solid aluminum 24 S. T. bar stock. Buffed finish eliminates plating time and costs, thereby speeding up delivery and service to your patients.

aluminum ball-bearing DROP-LOCK BRACE

Part No. 118
¼ x ⅝″ bar size—24 S. T. aluminum
Part No. 133
¼ x ½″ bar size—24 S. T. aluminum
Part No. 153
¼ x ¾″ bar size—24 S. T. aluminum

aluminum new style FRENCH LOCK BRACE

Part No. 160
¼ x ⅝″ bar size—24 S. T. aluminum
Part No. 161
¼ x ¾″ bar size—24 S. T. aluminum

QUALITY USMC

Specify and use aluminum braces manufactured by

UNITED STATES *Manufacturing* COMPANY

MANUFACTURERS of ALUMINUM and STEEL BRACE and ARTIFICIAL LIMB PARTS
3453 Glendale Boulevard, Los Angeles 39, Calif.

Late reconstruction of congenital esophageal atresia by intrathoracic colon transplantation.

Radiograph, 27 hours after birth, showing proximal esophageal pouch.

Two-year-old child prior to reconstruction.

Right colon mobilized.

Right colon lying on chest wall.

(For additional illustrations of this case, turn page)

See how radiography and photography work together

FIRST radiographs were made—as an integral part of the original diagnostic procedure. Next, photographs, in color, recorded the surgical procedure, step by step. Finally, as the patient recovered, post-operative radiographs verified the situation.

Here, another vivid illustration of the great value of radiography and photography when combined. *Per se*, each item is important; together, radiographs *and* photographs become a powerful chain of information—an invaluable, lasting instrument for teaching, review, research.

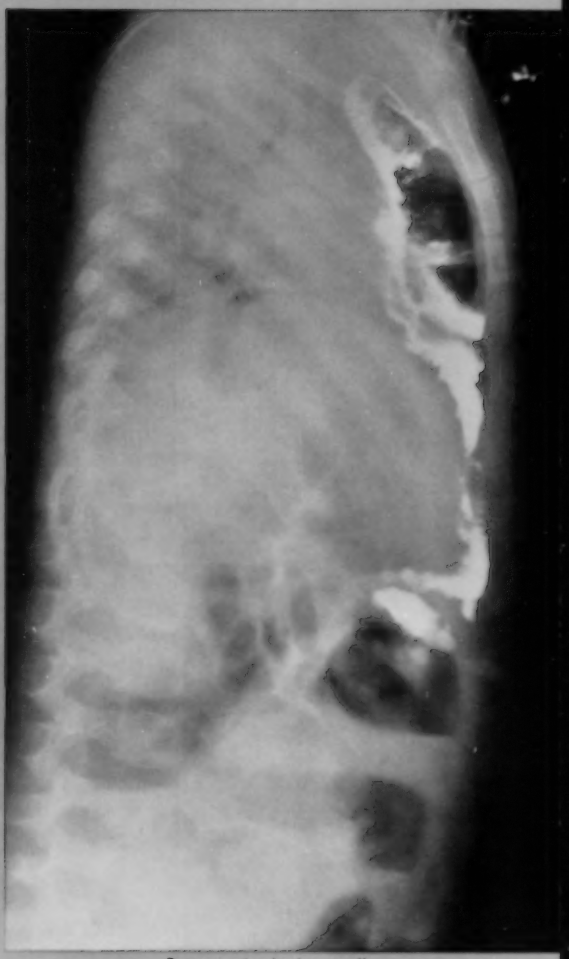
What is the cost? Very small indeed for the institution or the individual physician who combines radiography and photography as routine procedure.

Kodak
TRADE-MARK

Colon pulled through sub-sternal tunnel.

Anastomoses in progress.

Operation completed.



Postoperative barium swallow.

Radiographs and photographs, courtesy of The University of Rochester School of Medicine, Rochester, N.Y.

For Radiographs: Kodak Blue Brand X-ray Film and Kodak x-ray processing chemicals meet the most exacting requirements. They are always dependable—uniform. Quality controlled—rigidly tested—they are *made to work together.*

For Color Photographs: Kodachrome Film for miniature and motion-picture cameras (prices include processing by Kodak); Kodak Ektachrome Film and Kodak Ektacolor Film, Type B, for sheet-film cameras; Kodak Ektachrome Roll Film, Nos. 120 and 620, for roll-film cameras (can be processed locally).

Order x-ray products from your x-ray dealer, photographic products from your photographic dealer.

EASTMAN KODAK COMPANY, *Medical Division*, Rochester 4, N. Y.

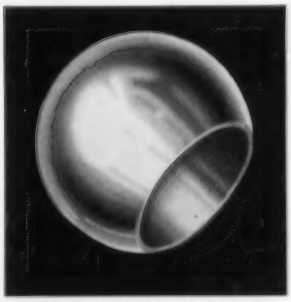
Kodak
TRADE-MARK

CRAWFORD ADAMS
Concentric HIP ARTHROPLASTY

A precise method of concentric arthroplasty, developed on sound engineering principles for the purpose of:

1. **Insuring concentric movement of the femoral head within the acetabular cavity.**
2. **Allowing only a small but uniform clearance between the moving parts.**
3. **Retaining the axial point of the femoral head as near to its normal position as possible.**

The Crawford Adams cup conforms with the "ball and socket" principle so that the joint acts concentrically about the normal axis of the hip.

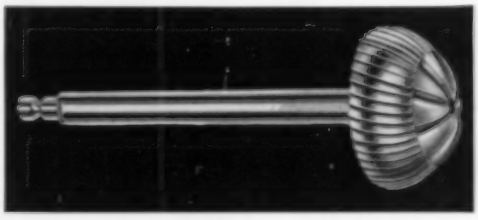


CONCENTRIC FEMORAL HEAD No. 701

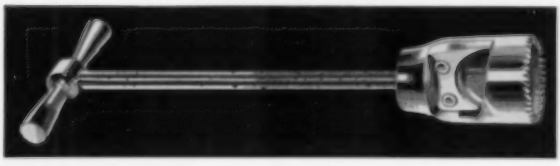
SMo stainless steel. Standard size meets 95% of all requirements. Extra large and extra small sizes available.

FEMORAL NECK REAMER No. 165

This reamer is made in two sections, with the object of achieving maximum cutting efficiency, and providing for easy clearance of the debris. Made from hardened and plated tool steel and in a size to ream acetabulum to insure precise fit of the concentric cup.



FEMORAL NECK SHAPER No. 164



A specially hardened stainless steel instrument designed to ream the femoral head and neck in one operation to the exact contour of the inside of the concentric cup.

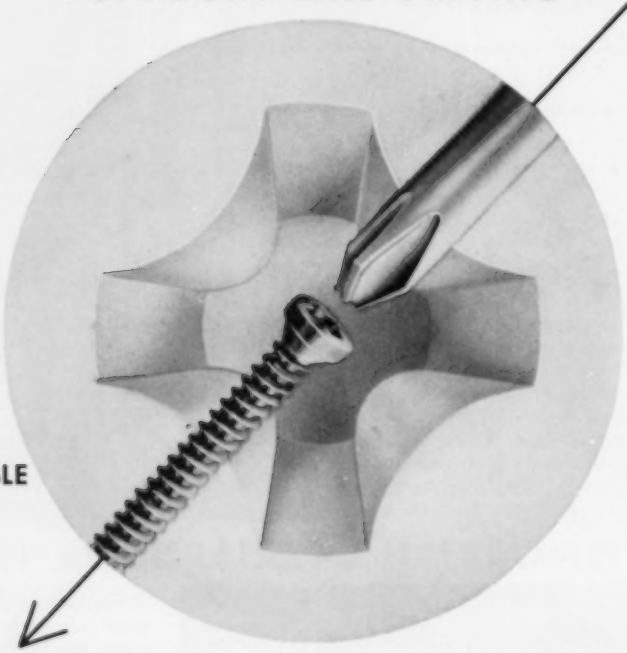
Full details of this technique were published in
THE JOURNAL OF BONE AND JOINT SURGERY, British Volume, May, 1953
Available through your surgical supply dealer

Orthopedic EQUIPMENT CO.
BOURBON, INDIANA
SPLINTS • FRACTURE EQUIPMENT • SMo INTERNAL BONE APPLIANCES • BONE INSTRUMENTS

Vitallium®

PHILLIPS RECESSED HEAD SCREW

- SUPERIOR HEAD STRENGTH
- STRAIGHT LINE DRIVING



- STRONG
- INERT
- COMPATIBLE
- PASSIVE
- RUGGED DRIVER
- SELF CENTERING
- NO DRIVER SLIPPAGE

Order Through Your Surgical Dealer

® By Austenal Laboratories, Inc.

AUSTENAL LABORATORIES, INC. *SURGICAL DIVISION*

224 EAST 39th STREET • NEW YORK 16, N. Y.

A GUIDE FOR NATURE'S REPAIR OF FRACTURED BONES

EGGERS TYPE

VITALLIUM®

INTERNAL CONTACT SPLINT

Encourages earlier bony union . . . assures optimum placement of screws . .

Vitallium Internal Contact Splints are slotted bone plates—permitting fractured bone ends to move together and to be in constant contact under muscular pressure when concurrent necrosis, absorption and osteogenesis of the traumatized bone ends occur. They keep the fractured bone in longitudinal alignment and provide lateral stability. Fragments are locked securely, and rotation is hindered by the combination of longitudinal muscular pull and screw fixation.

The Eggers splints thus serve as guides for nature's repair of fractured bones. Under the influence of splinting, compression, and contact, mechanical and physiological conditions favorable to early bone union are created.

The slots in the plates facilitate placing the screws in the most desirable locations—as far from the fracture site as possible. Loose bone fragments may be engaged firmly with additional screws.

ORDER THROUGH YOUR SURGICAL DEALER

Available in lengths of 3", 4", 5" and 6" with Eggers type screws.

References: "Internal Contact Splint" —Eggers, G.W.N. Jour. Bone & Joint Surg., 30-A, No. 1, Jan. 1948

"The Influence of The Contact-Compression Factor on Osteogenesis in Surgical Fractures" — Eggers, G.W.N., Shindler, T.O. and Pomerat, C.M., Jour. Bone & Joint Surg., 31-A, No. 4, Oct. 1949

® BY AUSTENAL LABORATORIES, INC.

AUSTENAL LABORATORIES, INC.
SURGICAL DIVISION

224 EAST 39th STREET • NEW YORK 16, N. Y.

New MOSBY Books

THE SHOULDER and ENVIRONS

By James E. Bateman, M.D., F.R.C.S. (C). *Diplomate American Board of Orthopaedic Surgery, Fellow American Academy of Orthopaedic Surgeons; Orthopaedic Consultant, Sunnybrook Hospital, Toronto. Department of Veterans Affairs of Canada; Consultant, Workmen's Compensation Board of Ontario.* 550 pages, 376 illustrations. Price, $16.25.

The book includes everything from Embryology to Assessment of Disability as applied to the shoulder area.

A system for arriving at the diagnosis and a classification of shoulder disease from the standpoint of symptoms is introduced so that the common disorders may be considered under three main headings: 1) conditions producing shoulder and neck pain; 2) conditions with shoulder pain predominating; 3) conditions with shoulder and radiating pain.

Treatment of all disorders is presented in detail. It is included with signs and symptoms and the pathology under the individual lesion.

Rehabilitation of the shoulder has been stressed. Exercise, physiotherapy, and occupational therapy routines are included.

FRACTURES, DISLOCATIONS and SPRAINS

Generally recognized as the "most comprehensive and practical source of information" on fractures, dislocations and sprains, this book gives only well-tried and reliably proved treatments. Compound open fractures have received special attention in this edition. A discussion of the use of medullary fixation of fractures of the femur and of the tibia have been added.

By John Albert Key *and* H. Earle Conwell. Fifth Edition. 1232 pages, 1195 illustrations. Price, $17.00.

ATLAS of ORTHOPEDIC TRACTION PROCEDURES

By Carlo Scuderi, B.S., M.D., M.S., Ph.D. *Clinical Associate Professor of Surgery, University of Illinois; Professor of Surgery, Cook County Graduate School.* 229 pages, 124 illustrations. Price, $12.50.

Gathered in this volume are the important features essential for successful use of orthopedic traction procedures. The illustrations concisely demonstrate the necessary features. Opposite the illustrations are given clear descriptions of the devices and the principles involved.

The purpose of this book is to fill a definite gap in orthopedic literature by photographs, line drawings and simple descriptive language. This type of book should facilitate the teaching of students, interns, and residents in the fracture and straight orthopedic services. It should also be of great help to the nursing profession and physical therapists who work with these patients.

LEGAL MEDICINE

Beside covering the usual subjects this book contains sections on Powder Burns, Hairs and Fibers, Dental Evidence in Identification and Criminology, and Lie Detection. Furthermore, it is the collaborative effort of 30 outstanding authorities — each chosen because of his proficiency and knowledge of certain aspects of Legal Medicine.

Edited by R. B. H. Gradwohl. 1093 pages, 222 illustrations. Price, $20.00.

Order Form

The C. V. MOSBY COMPANY Date.....
3207 Washington Boulevard, St. Louis 1, Missouri

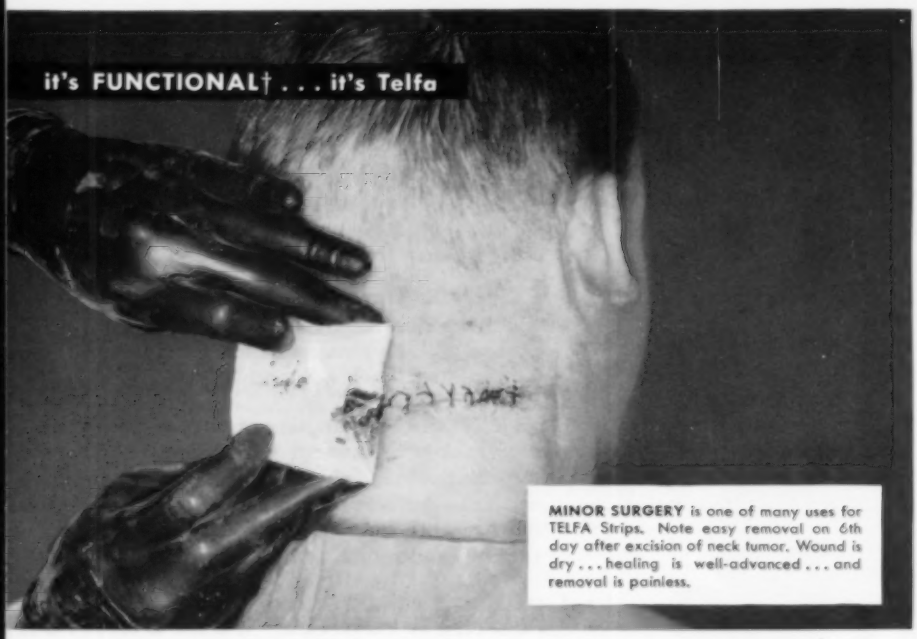
Gentlemen: Send me the book(s) checked with (X).

☐ Attached is my check
☐ Bateman "The Shoulder and Environs" $16.25
☐ Key-Conwell "Fractures" . . $17.00
☐ Charge my account
☐ Scuderi "Atlas of Orthopedic Traction Procedures" $12.50
☐ Gradwohl "Legal Medicine" . $20.00

Dr...... *Street*.....

City..... *Zone*..... *State*.....

JB&JS-4-55



MINOR SURGERY is one of many uses for TELFA Strips. Note easy removal on 6th day after excision of neck tumor. Wound is dry . . . healing is well-advanced . . . and removal is painless.

New Telfa dressing is first in history that

promotes primary wound healing

All-new, all-purpose TELFA is first completely non-adherent dressing that keeps wounds dry

Non-adherence, *plus* absorbency . . . that is the achievement of TELFA Strips, revolutionary new *Curity* dressing. It means, for the first time, an all-purpose dressing that keeps wounds dry without sticking—that encourages natural, uninterrupted healing.

ENTIRELY NEW PRINCIPLE—TELFA Strips consist of a non-wettable, perforated plastic film bonded to *Webril*® backing of 100% pure absorbent cotton. Used alone or with overlying dressings, it is applied with *film side* next to wound, and held with bandage or adhesive. Perforations pass drainage into pad, prevent reverse flow. And regenerating tissue can't grow into dressing.

TELFA COSTS LESS per patient than conventional dressings. Available in standard 2½" x 4" and 3" x 8" strips, in hospital cases; and in 2" x 3" sterilized envelopes for doctors.

NEW SIZE FOR PLASTIC SURGERY AND BURNS: *new 8" x 10" size is especially suitable for dressing donor and recipient skin-graft sites, and for extensive burns.*

Count on Curity for †DRESSINGS THAT WORK

Curity dressings are *functional* dressings—"built from the wound up" to promote faster healing. This is the *Curity* approach to better hospital dressings for better patient care. And the greater efficiency of *Curity* dressings means *lower cost per patient*—the true measure of dressings economy.

Curity

TELFA*

NON-ADHERENT STRIPS

BAUER & BLACK

Division of The Kendall Company
309 West Jackson Blvd., Chicago 6, Ill.

*Trade-mark of The Kendall Company

Reprint, Literature, Measuring Charts and Instructions Upon Request

The Jewett Brace . . .

for HYPEREXTENSION OF THE SPINE

COMPRESSION FRACTURES and other cases requiring positive hyperextension such as Osteoporosis with Kyphosis, Adolescent Epiphysitis and Marie Struempell's Spondylitis.

Rigidly performs function of body hyperextension cast; locked on patient when adjusted to proper hyperextension; not removed for bathing or sleeping; adjustable to physical changes, light, clean, sanitary, durable, conducive to physiotherapy and return to light duties.

FLORIDA BRACE CORPORATION

★ Box 1366, 1151 Harmon Avenue Winter Park, Florida

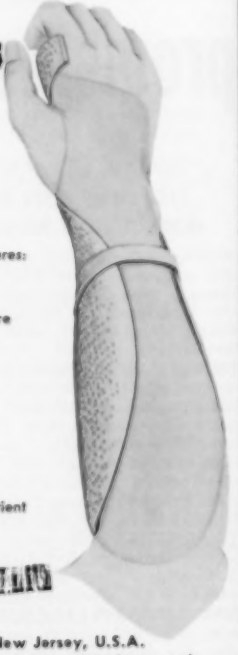
NEW! **DIREKT-FORM, for Prosthetic devices**

IMPROVE YOUR ORTHOPEDIC APPLIANCES

DIREKT-FORM aluminum-alloy wire and woven fiber mesh is a new, patented material. The mesh is easily formed directly to the body of the patient. This molded form is then dipped into the plastic hardener. Also, the DIREKT-FORM method has a unique advantage over plaster. A special softener is supplied which permits reshaping or adjustment of a semifinished or finished DIREKT-FORM device.

These are important DIREKT-FORM features:

- √ Eliminates plaster casts
- √ Can be handled at room temperature
- √ Simple technique
- √ Light-weight and durable
- √ Readily reshaped
- √ Allergy-proof, easily sterilized
- √ Radiolucent
- √ Cosmetically more appealing to patient



Write today for Bulletin of Technique

DIREKT-FORM

151 Hackensack Avenue, Hackensack, New Jersey, U.S.A.

EXCLUSIVE NATIONAL FRANCHISES AVAILABLE—for many countries. Write for proposal.

new ELASTICFOAM

TRADEMARK

the velvet-soft elastic bandage
that stays in place like a second skin

ELASTICFOAM is a completely new type of bandage which combines the best properties of adhesive plaster, elastic, and cotton bandages. It is made by permanently bonding a sheet of multi-slit foam rubber to a superior quality cotton elastic bandage.

ELASTICFOAM stays in place like adhesive plaster—shaving is eliminated, redressing easy and painless.

Fully elastic (stretch 100%), does not narrow, maintains uniform pressure.

Velvet-soft and highly absorbent — may be applied directly over wounds, absorbs at least 5x its own weight of moisture.

ELASTICFOAM can be autoclaved. Economical — may be washed, sterilized and reused many times.

No allergic reactions reported after repeated application, does not mat under plaster casts nor interfere with X-ray.

knee, ankle, wrist, elbow, chest and back injuries

compression treatment of varicose veins, ulcers, phlebitis

postoperative dressings

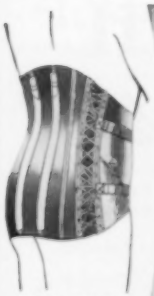
in place of orthopedic felt

sports strapping—ankles, etc.

Elasticfoam bandages are 5 yards long when stretched, made in 2", 3", 4", 6", 8" widths, ⅛" and ¼" thicknesses. Available by the square yard for casts and other orthopedic work.

You must see and handle this unique bandage to appreciate its many advantages. Write for descriptive booklet and sample of Elasticfoam.

CONNECTICUT BANDAGE MILLS INC., POLAND STREET, BRIDGEPORT, CONN.



FOR MEN

YOU CAN PRESCRIBE

Freeman
BACK SUPPORTS

WITH CONFIDENCE

FOR WOMEN

By working closely with the medical profession for over 60 years, Freeman has developed a complete line of surgical supports. From this line you can select and prescribe with complete confidence in the suitability of each garment for its purpose, in the quality of its construction and in the comfort it will give the wearer.

Freeman corset-type back supports are made in models which provide supportive and conservative measures in any required degree to almost complete immobilization. The great advantage of this type of garment is that *it can be worn comfortably while sitting, standing or lying.* In addition to correct design and fine construction, Freeman supports embody many improvements, to increase comfort and convenience for the wearer. For example, linings and stay covers are cushioned for comfort. All side-laced back supports have Freeman's exclusive self-smoothing, non-wrinkle fly.

Mail coupon for details of Freeman quality feature and free pocket-size reference catalog.

FREEMAN MANUFACTURING COMPANY
DEPT. 704 STURGIS, MICHIGAN

Please send details on new Freeman features and include free reference catalog.

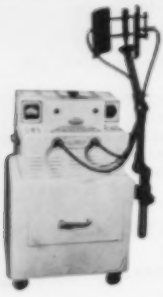
Name_____

Address_____

City_____ State_____

these units are the *criterion*

MODEL 3000 ULTRA SOUND



MODEL 1200 MASTER FISCHERTHERM

In diathermia and ultra sonics

Two ultra sound machines are manufactured by the pioneer R. A. FISCHER & CO., leader in electro-therapy equipment. Shown is the Model 3000 Console, one of the finest units presently available. Model 3000 offers CONTINUOUS ULTRA SOUND plus **IMPULSE ULTRA SOUND** (successful treatment without heat). Companion to the Model 3000, the Model 2500 Portable is not illustrated. Both units reflect outstanding craftsmanship—each is guaranteed a full year. Contemporary cabinets are finished in off-white enamel and in gray hammertone metallic, with special colors on request. The 3000 unit sells for $495.00 and the Model 2500 is $345.00 (FOB Glendale, Calif.). Further details will be sent immediately on your request.

In diathermia no machine surpasses the performance of the Model 1200 CONSOLE MASTER FISCHERTHERM. Power output is more than ample for heaviest therapeutic demands. The cabinet is finished in off-white enamel and in gray hammertone metallic—special metallic finishes in shades of maroon, blue or green are available on request. The hinged electrode set (Catalog No. 1202) is purchased separately at $109.00. Price of the MASTER FISCHERTHERM Model 1200 is $654.50 FOB Glendale, California. A full year guarantee, of course. Your request for details will be promptly handled by our office staff.

FISCHER

R. A. FISCHER & CO.
Manufacturers of Electro-Therapy Equipment
525 Commercial Street, Dept. K • Glendale 3, California

THE PUGH HIP-NAIL

PAT. PEND.

'Self Adjusting'

Only 4 SIZES REQUIRED

FORGED PLATES IN 3, 4, 5 AND 6 INCH LENGTHS
KEY AND GROOVE PREVENTS ROTATION.
FRICTION RING IN TUBE FURNISHES CONSTANT TENSION.

AN APPLIANCE DEVISED TO GIVE MORE ADEQUATE FIXATION FOR FRACTURES OF NECK OF THE FEMUR AND INTERTROCHANTERIC FRACTURES WITH MANY ADVANTAGES.

FOR ADDITIONAL INFORMATION CONTACT THE MANUFACTURER

1. It allows impaction of the fractured fragments without fear of the nail penetrating the hip joint.
2. It prevents distraction of the fractured fragments.
3. The nail is so constructed that only the plate length needs to be varied as adjustability of the nail adapts the appliance for use in almost all fractures about the upper end of the femur. This feature reduces the nail inventory. The unusual strength and adjustability offers additional advantages.

MANUFACTURED BY
KEN STANDARD CORP.
EVANSVILLE, INDIANA

Fillauer DETACHABLE NIGHT SPLINT

Advance Improvements

Orthopedic surgeons are enthusiastic about this versatile splint. It affords decided advancements for treating club feet, positional deformities, tibial torsions, flat feet, congenital hip dislocations. Use of the Fillauer Splint minimizes the necessity of manipulations, plaster, tenotomies and anesthetics. Satisfactory results are confined to children under 3 to 4 years of age.

Write for descriptive folder.

● Stainless bronze serrated discs permit 50 different rigid settings. Fits any shoe—double-post swivel clamp and single lateral clamp adjust easily to any shoe up to 4-yr. old sizes. Special flange for club foot or wedged shoes.

FILLAUER SURGICAL SUPPLIES, INC.

Box 1678, CHATTANOOGA, TENNESSEE

Manufacturers of Orthopedic Appliances ESTABLISHED 1914

Where traction is indicated use . . .

tractolator*

MOTORIZED INTERMITTENT TRACTION

*Reg. U.S. Patent #2633124—2633125

Now the physician can administer a carefully graduated, smooth traction force . . . precisely, automatically . . . intermittently, with maximum comfort to the patient . . . of greater traction force than ever before—up to 50 lbs. cervical, up to 100 lbs. pelvic!

As illustrated, TRACTOLATOR is made in both chair and bed models, the latter for bed patients and hospital cases. Bed traction is used for pelvic traction and can be adapted for cervical traction by using a single pulley and cable with head halter attachments.

ACCEPTED COUNCIL ON PHYSICAL MEDICINE and REHABILITATION AMERICAN MEDICAL ASSOCIATION

Distributed Exclusively by

LOUIS YELLIN, INC.

Philadelphia, Pa.

Manufactured by

TRACTOLATOR COMPANY, INC. 242 S. 17th St. Phila. 3, Pa.

VITAGENIC!

EXTRA-FIRM mattress

Made according to the exact requirements of the physician or registered orthopaedic specialist! Designed to relieve the backache of spinal or sacro-iliac injury!

CHECK THESE FEATURES:

- ✓ A rigid mattress and boxspring combination requiring no interposed boards.
- ✓ Hand-stitched sidewalls so firm it permits patients to get in and out of bed easily.
- ✓ Resilient surface — provided by curled hair — will not tend to stop circulation or cause undue pressure on nerve points.
- ✓ Guaranteed for 15 years.
- ✓ Created by King Karpen, originator of the world-famous Hollandaire mattress — long the first choice of fine hotels.

CONTACT YOUR NEAREST AIRELOOM DEALER OR WRITE:

Aireloom BEDDING
created by *king karpen*
1119 Westminster Ave., Alhambra, Calif.

Two-Way Stretch

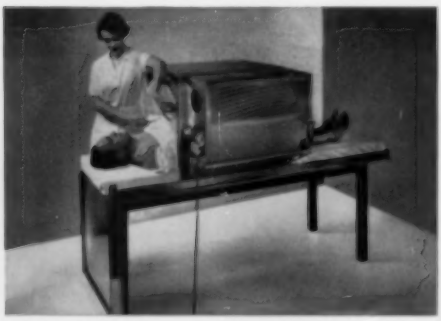
NYLON LASTEX STOCKINGS

Closed heel, open toe, full fashioned to fit. Made for both men and women. Take measurements at largest part of calf.

Our Price
$7.00
PER PAIR

We also make Sacroiliac belts $4.50; Sacro-lumbar belts $6.50; Abdominal belts, braces, etc. Write for our separate catalogue on Elastic Stockings, Abdominal Belts, Orthopaedic Appliances, or Prostheses.

the F. A. RITTER COMPANY
4624 Woodward Avenue — Detroit 1, Michigan



MOISTAIRE
The Original Heat Therapy Unit

UNEXCELLED
for the delivery of moist heat at the exact prescribed temperature.

COMFORT • SAFETY • DURABILITY

MOISTAIRE accepted and approved since 1944 by the Council on Physical Medicine and Rehabilitation (AMA) and Underwriters' Laboratories.

For illustrated information write, wire or call:

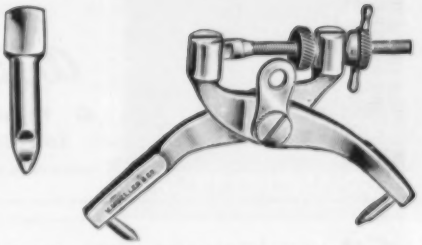
The RIES *Corporation*
515 SOUTH AIKEN AVE., PITTSBURGH 32, PA.

THE IMPROVED MODEL

CRUTCHFIELD SKELETAL TRACTION TONGS

The advantages of skeletal traction over other methods of treating injuries to the cervical spine have made the Crutchfield Traction Tongs a standard instrument with many surgeons. This improved model, with the proper open spread of 11 cm. from point to point, has pins which have been redesigned so that most of their pressure rests against the outer table of the skull. This minimizes pressure necrosis and overcomes the possible penetration of thin skulls. The instrument is stainless steel.

(The Crutchfield technique is described in detail in ARMAMENTARIUM, *Vol. 2, No. 3. Your complimentary copy will be sent to you upon request.)*



Inset (*actual size*) shows detail of the improved, safer point.

CRUTCHFIELD Skeletal Traction Tongs, improved model. *Each* $24.00

Drill Point, 1/8", for use with above. *Each* $3.50

Drill Point, 3/16", for use with above. *Each* $3.50

V. Mueller & Co.

Instrument Makers to the Profession Since 1895

330 South Honore St., Chicago 12, Illinois

BRANCH STORES NOW IN DALLAS AND HOUSTON, TEXAS — ROCHESTER, MINN.

IN THE HOSPITAL
Hydrocollator Master Unit maintains ready supply

IN THE HOME
Heat in any vessel on stove

NO WRINGING
NO DRIPPING

WRAP IN TOWEL

30 MINUTES MOIST HEAT WITH EACH APPLICATION

APPLY

EFFECTIVE
MOIST HEAT
EASILY APPLIED
HYDROCOLLATOR
Steam PACK

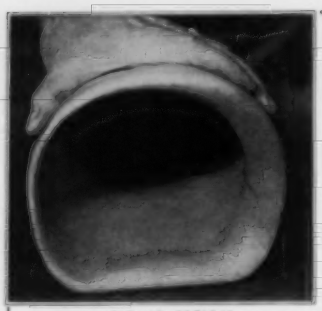
Everyone agrees moist heat is most effective in reducing spasm and pain. Now it can be easily and efficiently applied! Hydrocollator Steam Packs require no wringing, won't drip, are easy to prepare and handle. In use in leading hospitals and treatment centers.

ACCEPTED BY THE COUNCIL ON PHYSICAL MEDICINE AND REHABILITATION (AMA)

WRITE FOR DESCRIPTIVE FOLDER

CHATTANOOGA PHARMACAL COMPANY, INC.

CHATTANOOGA 5, TENNESSEE



PAT. NO. 2253040

THE UNITED LIMB AND BRACE CO., INC.

61 HANOVER STREET BOSTON 13, MASSACHUSETTS

Telephone: CApitol 7-2183

Manufacturers of

Artificial Limbs

This shows how the

Soft Back Rubber Cushion Socket

conforms to the stump when the patient is sitting down

ACCREDITED

Clarks promise

Clarks promise freedom from all foot troubles caused by footwear, if from babyhood none but Clarks shoes are worn, fitted by Clarks Footgauge.

Clarks back this promise with 129 years of shoe craftsmanship. They *keep* it by making children's shoes which are based on the natural shape of a child's foot . . . in different widths to each length size . . . fitted with scientific accuracy on a special Footgauge for *length*, for *breadth* and for *girth*.

MADE BY C. & J. CLARK LIMITED
(WHOLESALE ONLY), STREET, SOMERSET

Available • **NOW** • *the Improved*

Frejka

ABDUCTION PILLOW SPLINTS

For congenital dislocation of the hip in the newborn and in early postnatal life. (As described by Dr. V. L. Hart, J. Bone and Joint Surg., Vol. 31-A, pp. 357–372, April 1949, and J.A.M.A., August 12, 1950, Vol. 143, pp. 1299–1303. See also Orthopaedic Appliances Atlas, Vol. 1 — 1952.)

Three Sizes: SMALL — up to 3 months; MEDIUM — 3 to 6 months; LARGE — over 6 months.

One Halter, One Pillow **$7.75**

Two Halters, One Pillow **$12.50**

Choice of colors: white, yellow, and pink. Orders filled immediately — shipped postpaid.

MINNESOTA ORTHOPEDIC SERVICES

1963 Carl Street

ST. PAUL 8, MINNESOTA

WILLIAMS

LUMBO-SACRAL BRACE

Measurements: 1. Chest (about 4″ below nipple line); 2. Waist (at navel line); 3. Pelvic (½ distance between greater trochanter and crest of ilium); 4. Seventh cervical spinous process to sacrococcygeal junction.

ALL ORTHOPAEDIC APPLIANCES

Orders filled at the request of members of the profession only

MILLER BRACE CO.

3902 Gaston Avenue Dallas, Texas

For prompt service use our P. O. Box 7902

PRESTON

A COMPLETE LINE FOR PHYSICAL MEDICINE AND

REHABILITATION

ALL TYPES OF THERAPEUTIC EXERCISE EQUIPMENT: Bicycles, **Shoulder Wheels,** Quadriceps Boots, **Hand Rehabilitation Devices,** Bunnell Splints, Kanavel Table, Walking Parallel Bars, Staircases, Posture Mirrors, **Gym Mats,** Guthrie-Smith Suspension Apparatus.

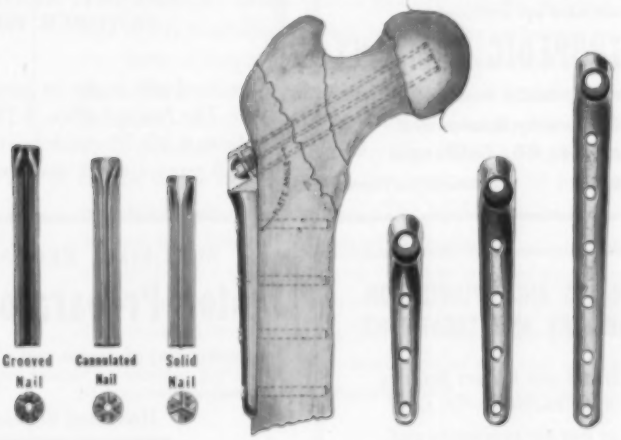
Cervical Traction Sets, Tractolator, **Whirlpools,** Paraffin Baths, **Hydrocollator,** Electro Therapeutic Apparatus, Goniometers, Treatment Tables, **E & J Wheelchairs,** Walkers, Patient Lifters, C.P. Equipment, Self-Help Devices.

We supply all equipment for setting up a complete Rehabilitation Program in offices and hospital departments and are glad to assist in planning these. Your inquiries are invited.

Write for your free copy of our new illustrated Equipment Manual #1056

J. A. PRESTON CORP.
175 FIFTH AVENUE, NEW YORK 10, N. Y.

THORNTON PLATES FLANGED NAILS
for
Treatment of Fractures of the Femur and Trochanter



Price Filler Machine & Mfg. Co.

508 Rorer Avenue, S. W.
ROANOKE, VIRGINIA

A MODERN CORRECTIVE SHOE
FOR EVERY *Orthopedic* NEED

TARSO SUPINATOR®
For the postural correction of flat feet.

TARSO PRONATOR®
For club feet and metatarsus varus. Pairs or single shoes.

TARSO MEDIUS®
Straight, neutral last shoe. Detailed to match Tarso Pronator. Pairs or single shoes.

Tarso shoes are fitted on prescription at better shoe stores. Write for nearest dealer or use your regular supplier. Brochure on request.

M. J. MARKELL SHOE COMPANY, INC.
332 S. Broadway, Yonkers, N. Y.

ILFELD

HIP ABDUCTION SPLINT

Indicated in cases of:

- DYSPLASIA
- CONGENITAL-HIP DISLOCATION
- PERSISTENT PIGEON-TOES

Illustrated forms upon request

MAIL ORDERS FILLED PROMPTLY

manufactured and distributed by

ACE ORTHOPEDIC COMPANY

HY CHRISTENSEN, *Manager*

8473 Beverly Boulevard
Los Angeles 48, California

WEbster 3-3040 Representatives Wanted

WANTED

Copies of
THE JOURNAL OF
BONE AND JOINT SURGERY

Issues of . . .

JANUARY 1931
JANUARY 1937
OCTOBER 1937
OCTOBER 1939
JANUARY 1940
JANUARY, APRIL and
OCTOBER 1944

• Send any copies in good condition to *The Journal* office, 8 The Fenway, Boston 15, Massachusetts, and you will receive check promptly.

INSTRUMENTS AND SPLINTS FOR HAND SURGERY AND TREATMENT

Active Hand *and* **Finger Splints**
(Cock-up, Knuckle-bender, etc.)

Torsion Bar *for supination and pronation of the wrist*

Tendon-Stripping Instruments

Anvil *for the small bones of the hand*

Gig Pull-Out Suture *with attached needle for tendons*

Small Hand Drill
for use with Kirschner wire drills

and other special instruments for bone and joint surgery

Write for our Catalogue

H. WENIGER
Established 1907
143 Valencia St. San Francisco 3

SURGEONS RECOMMEND

Boston Preparatory Limbs

For conditioning of stumps, and morale building, by permitting amputee to become ambulatory at earliest possible date.

Hospital Service

SUCTION SOCKET LIMBS

LATEST DEVELOPMENT IN PLASTIC LAMINATE ARMS (in accordance with National Research Council procedure)

PERMANENT LIMBS *of* English Willow *and* Alcoa Aluminum

BOSTON ARTIFICIAL LIMB CO., Inc.
"Certified Prosthetists"
Oldest and largest Limb Mfg. Co. in New England
69 Canal Street *Tel.: La. 3-6548* Boston, Mass.

NEW AND IMPORTANT!

Operative Orthopedic Clinics

By LEWIS COZEN, M.D., F.A.C.S. *and* ALVIA BROCKWAY, M.D.,
in collaboration with PAUL E. MacMASTER, M.D., F.A.C.S.

A Factual Approach Based on Actual Experiences in the Operating Room

This book practically places the orthopaedic surgeon at the side of his confreres as they work in the operating rooms of two busy orthopaedic services . . . Wadsworth General Hospital, West Los Angeles, and the Los Angeles Orthopedic Hospital. More than 200 selected case experiences are reviewed thoroughly — 58 on the hip, 29 the knee, 14 the spine, 28 the upper extremity, 44 foot and ankle, 39 fractures, 14 plastic repairs (head to toe). The book, rich in illustration, follows this general pattern of presentation . . . the method and procedure decided upon, why the plan of operation was chosen, preoperative and postoperative considerations, running commentary summarizing the findings in each step during the operation, and a presentation of the case as it applies to general operative procedures in the field under examination.

There is an appendix — a section on instruments — and an index.

329 PAGES 310 ILLUSTRATIONS PUBLISHED 1955

AN OUTSTANDING BOOK THAT DESERVES YOUR EARNEST CONSIDERATION . . . NOW!

LIPPINCOTT BOOKS

PHILADELPHIA • MONTREAL

J. B. LIPPINCOTT COMPANY
East Washington Square, Philadelphia 5, Pa. *In Canada—2083 Guy Street, Montreal, P. Q.*

Please send me, with the privilege of returning it within 10 days if not satisfied;
OPERATIVE ORTHOPEDIC CLINICS.....$10.00
☐ CASH ENCLOSED ☐ CHARGE MY ACCOUNT

Name.....
Address.....
City..... Zone..... State.....

Is Your File Complete?

Many subscribers to *The Journal of Bone and Joint Surgery* have their volumes bound each year for their reference libraries.

Calls for back issues during recent months have depleted the supply of some numbers.

If you lack certain numbers and wish to complete your file of *The Journal*, you should promptly ascertain if the missing numbers are available. (Not all issues are available.)

Single copies of issues 1948–1954 ..... $2.50 each
Single copies of issues 1922–1947 ..... 1.50 each
Single copies of issues 1916–1921 (monthly)..... .50 each

Write to:

THE JOURNAL OF BONE AND JOINT SURGERY
8 The Fenway Boston 15, Massachusetts

List of Advertisers—April 1955

	PAGE
Ace Orthopedic Company	68
Aeroplast Corporation	8
Aireloom Bedding Company	64
C. H. Alden Shoe Company	29
American Cancer Society	51
American Safety Razor Corporation	13
Astra Pharmaceutical Products, Inc.	15
Austenal Laboratories, Inc.	56, 57
Ayerst Laboratories	33, 48
Bauer & Black, Div. of The Kendall Co.	31, 59
The Berivon Company	46, 47
Boston Artificial Limb Co., Inc.	68
Bowen & Company, Inc.	49
S. H. Camp and Company	43
Chattanooga Pharmacal Company, Inc.	65
C. & J. Clark Limited	66
Codman & Shurtleff, Inc.	30
Connecticut Bandage Mills, Inc.	61
Davis & Geck, Inc., Unit of the American Cyanamid Company	27, 28
DePuy Manufacturing Co., Inc.	16
Direkt-Form Company	60
Eastman Kodak Company	53, 54
Elgin Exercise Appliance Co.	26
Fillauer Surgical Supplies, Inc.	63
R. A. Fischer & Co.	62
Florida Brace Corporation	60
Freeman Manufacturing Company	61
Hanger Prostheses	45
Jacuzzi Bros., Inc.	42
Johnson & Johnson	9, 10, 11
Ken Standard Corporation	62
Kleistone Rubber Company, Inc.	12
J. B. Lippincott Company	69
M. J. Markell Shoe Company, Inc.	67
S. E. Massengill Company	37, 38, 39, 40
Medical Research Specialties	36
Miller Brace Co.	66
Minnesota Orthopedic Services	66
The C. V. Mosby Company	58
V. Mueller & Co.	65
Orthopedic Equipment Co.	55
Orthopedic Frame Company	4, 5
Pfizer Laboratories, Division, Chas. Pfizer & Co., Inc.	18, 19
J. A. Preston Corp.	67
Price Filler Machine & Mfg. Co.	67
Richards Manufacturing Company	20, 21, 22
The Ries Corporation	64
F. A. Ritter Company	64
I. Sabel, Inc.	34
Chas. A. Schmidt Surg. Inst. Co.	41
The Selby Shoe Company	17
Smith-Dorsey, Division of The Wander Co.	23
Thompson Bros. Shoe Co.	34
The Tower Company	25, 35
Tractolator Company, Inc.	63
Truform Anatomical Supports	24
The United Limb and Brace Co., Inc.	66
United States Manufacturing Company	52
H. Weniger	68
The Williams & Wilkins Company	32
Winthrop-Stearns, Inc.	44
Wright Manufacturing Company	14
Louis Yellin, Inc.	63
Zimmer Manufacturing Co.	6, 7

In answering advertisements, please mention *The Journal of Bone and Joint Surgery.*

ADDRESSES OF CONTRIBUTORS

APRIL 1955

HANS H. BOHR, M.D., Skive Sygehus, Skive, Denmark

H. B. BOYD, M.D., 869 Madison Avenue, Memphis 3, Tennessee

THOMAS F. BRODERICK, JR., M.D., 1265 Beacon Street, Brookline, Massachusetts

DONAL BROOKS, F.R.C.S., 234 Great Portland Street, London, W.1, England

R. A. CALANDRUCCIO, M.D., University of Tennessee Medical School, Memphis, Tennessee

GENE D. CALDWELL, M.D., 803 Jordan Street, Shreveport, Louisiana

E. GEORGE CHUINARD, M.D., 1922 N. W. Johnson Street, Portland 9, Oregon

PATRICK CLARKSON, F.R.C.S., 107 Harley Street, London, W.1, England

PROF. P. K. DURAISWAMI, Safdarjang Hospital, New Delhi 3, India

G. W. N. EGGERS, M.D., University of Texas — Medical Branch, Galveston, Texas

SIDNEY N. EICHENHOLTZ, M.D., 130 West Kingsbridge Road, Bronx 68, New York

H. B. EISENSTADT, M.D., 2301 Procter Street, Port Arthur, Texas

DAVID S. GRICE, M.D., 300 Longwood Avenue, Boston 15, Massachusetts

J. ALBERT KEY, M.D., 4952 Maryland Avenue, St. Louis 8, Missouri

JACK LEVINE, M.D., 20 Plaza Street, Brooklyn 38, New York

MYER MAKIN, M.B., M.R.C.S., Hadassah University Hospital, Jerusalem, Israel

LEO MAYER, M.D., 1150 Fifth Avenue, New York 28, N. Y.

VICTOR MAYER, M.D., 532 Park Avenue, New York 21, N. Y.

R. A. MURRAY, M.D., Scott and White Clinic, Temple, Texas

CHARLES S. NEER, II, M.D., 180 Fort Washington Avenue, New York 32, N. Y.

ALONZO J. NEUFELD, M.D., 1216 Wilshire Boulevard, Los Angeles 17, California

VERNON L. NICKEL, M.D., 1216 Wilshire Boulevard, Los Angeles 17, California

R. H. RAMSEY, M.D., 4952 Maryland Avenue, St. Louis 8, Missouri

MONROE SCHNEIDER, M.D., 118 Eighth Avenue, Brooklyn 15, New York

SAMUEL SCHORR, M.D., Hadassah University Hospital, Jerusalem, Israel

A. R. SHANDS, JR., M.D., P. O. Box 269, Wilmington, Delaware

G. MOSSER TAYLOR, M.D., 1216 Wilshire Boulevard, Los Angeles 17, California

T. CAMPBELL THOMPSON, M.D., 321 East 42nd Street, New York 17, N. Y.

D. B. ZILVERSMIT, PH.D., University of Tennessee Medical School, Memphis, Tennessee

RUMFORD PRESS
CONCORD, N. H.